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Characterization Well R-14 Completion Report

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Produced by the Groundwater Protection Program, Risk Reduction & Environmental Stewardship Division

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List of Acronyms and Abbreviations

AITH	array induction tool, version H
ASTM	American Society for Testing and Materials
bgs	below ground surface
CNTG	compensated neutron tool, model G
DH	down-hole
DOE	US Department of Energy
DQO	data quality objective
DR	dual rotary
DTH	down-the-hole
ECS	elemental capture spectroscopy
ER	Environmental Restoration (Project)
ESH	Environmental, Safety, and Health
FMI	formation microimager
FMU	Facility Management Unit
GIT	groundwater Investigations Team
GPS	global positioning system
hp	horsepower
ID	inner diameter

LANL	Los Alamos National Laboratory
NGS	natural gamma spectroscopy
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
OD	outer diameter
psi	pounds per square inch
PVC	polyvinyl chloride
RC	reverse circulation
RRES	Risk Reduction and Environmental Stewardship Division
SAP	sampling and analysis plan
SSHASP	site-specific health and safety plan
TA	technical area
TD	total depth
TKN	total Kjeldahl nitrogen
TLDM	triple detector litho-density
UDR	universal drill rig
UR-DTH	under-reaming down-the-hole (hammer)
VOC	volatile organic compound
WCSF	waste characterization strategy form
WGII	Washington Group International, Inc.

Metric to US Customary Unit Conversions

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (μm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (μg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

CHARACTERIZATION WELL R-14 COMPLETION REPORT

ABSTRACT

Characterization well R-14 was installed under the implementation of the "Hydrogeologic Workplan" (LANL 1998, 59599). The Nuclear Weapons Infrastructure, Facilities, and Construction Program funded this well, and the project was directed by the Environmental Restoration Project in accordance with the "Work Plan for Mortandad Canyon" (LANL 1997, 56835). Management of the drilling program was carried out by Washington Group International, Inc., under a subcontract to the Los Alamos National Laboratory (LANL or the Laboratory). The well is located in Ten Site Canyon, a tributary to Mortandad Canyon in the east-central portion of the Laboratory. It is downgradient of the active radioactive liquid waste treatment facility at Technical Area (TA)-50 and the former radioactive liquid waste and septic facilities at TA-35. This well is primarily designed to determine whether Laboratory releases and treatment plant effluents may be present in and around the Mortandad Canyon watershed and, if so, the extent to which contaminants affect groundwater quality.

In addition, hydrologic, geologic, geochemical, and geophysical information obtained during completion and subsequent sampling of this well will provide data to evaluate the hydrologic setting of Mortandad Canyon and contribute to implementing a Laboratory-wide groundwater monitoring network. Data from R-14 and similar wells support the Laboratory's Groundwater Protection Management Program Plan.

Core drilling was performed at R-14 to the depth of 306 ft. The R-14 borehole was then drilled to a total depth 1327 ft using air-rotary/fluid assisted and conventional mud-drilling methods. Samples of drill cuttings were collected at regular intervals for stratigraphic, petrographic, and geochemical analysis. Geologic strata encountered during drilling operations at R-14 included, in descending order, the Tshirege Member of the Bandelier Tuff; the Cerro Toledo interval of the Bandelier Tuff; the Otowi Member of the Bandelier Tuff, including the Guaje Pumice Bed; upper Puye Formation sediments; dactite lavas; and a sedimentary sequence making up a lower section of Puye Formation and underlying pumiceous sediments.

No perched water zones were encountered at R-14. The regional zone of groundwater saturation was encountered at a depth of 1182 ft in the Puye Formation. Groundwater samples were collected from the regional aquifer during well development to analyze selected organic and inorganic constituents, stable isotopes, and radionuclides.

Well installation was completed on July 02, 2002. Two screened intervals were placed within the regional aquifer. Straddle-packer injection tests were conducted on screen 2. A Westbay™ multiport system for groundwater sampling was installed in the well casing.

1.0 INTRODUCTION

This completion report summarizes the preparation, drilling, well construction and development, and related activities performed at the characterization well R-14 drilling site from May 16, 2002, to February 21, 2003. Well R-14 is located in Ten Site Canyon, a tributary to Mortandad Canyon in the east-central portion of the Los Alamos National Laboratory (LANL or the Laboratory) (Figure 1.0-1). This well is downgradient of the active radioactive liquid waste treatment facility at Technical Area (TA)-50 and of former radioactive liquid waste and septic facilities at TA-35.

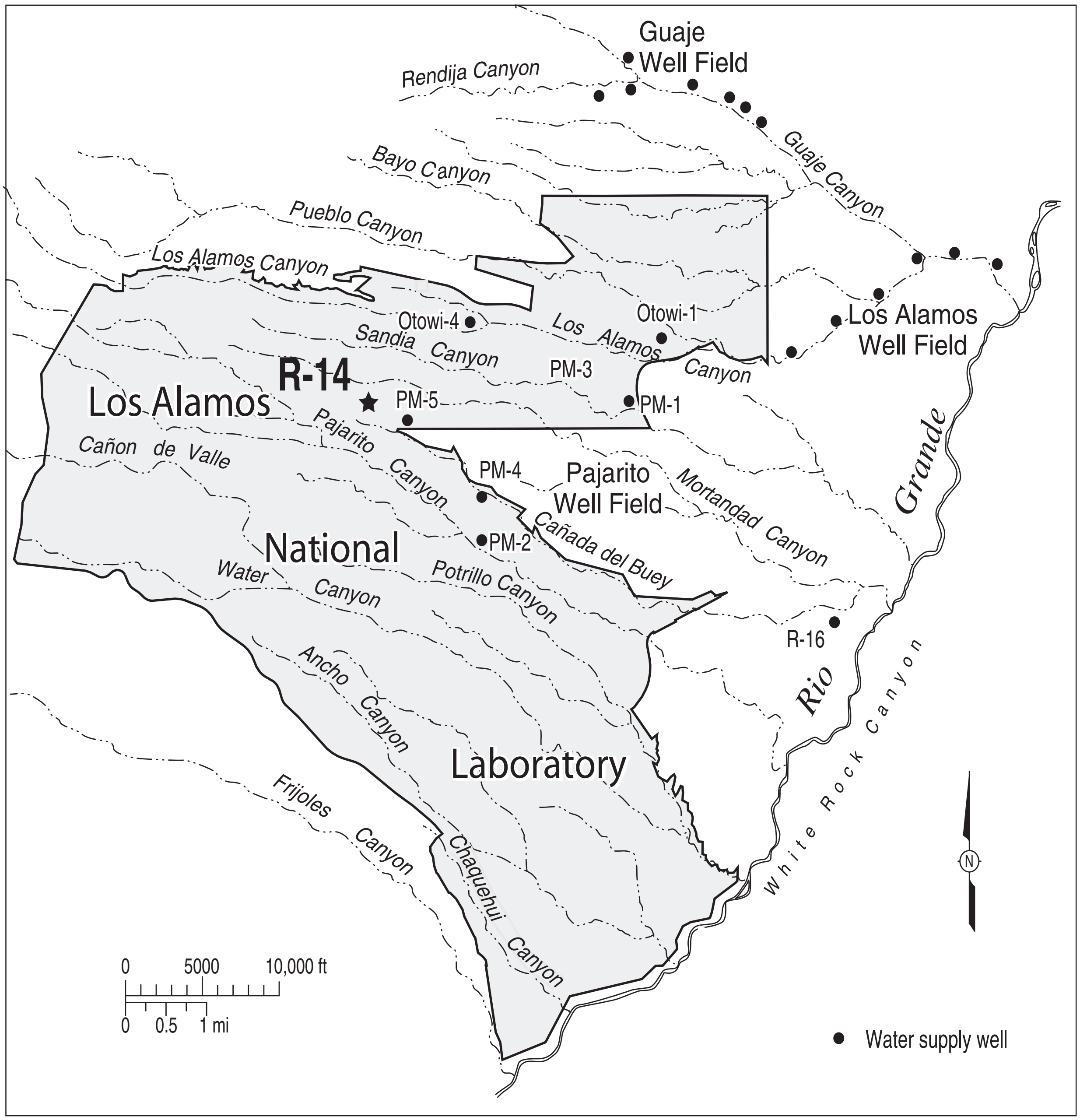


Figure 1.0-1. Map showing location of characterization well R-14

This well completion report focuses on operational activities associated with the drilling, sampling, and completion of well R-14. The information presented here was compiled from field reports and activity summaries generated by the Laboratory and the drilling subcontractor. Geophysical data and geodetic survey information are also included. Data from R-14 and similar wells support the Laboratory's Groundwater Protection Management Program Plan.

Results of these activities are discussed briefly and shown in tables and figures contained in this report. Detailed analysis and interpretation of geologic, geochemical, geophysical, and hydrologic data will be included in separate technical documents to be prepared by the Laboratory.

Well R-14 was funded by the Nuclear Weapons Infrastructure, Facilities, and Construction Program and installed by the Laboratory's Environmental Restoration (ER) Project, now called the Risk Reduction and Environmental Stewardship (RRES) Division. Washington Group International, Inc. (WGII), under contract to the Laboratory, was responsible for executing drilling activities.

The potential sources of groundwater contamination of most concern at R-14 are the present-day radioactive liquid waste treatment plant at TA-50 and the former radioactive liquid waste treatment plant at TA-35. R-14 primarily is designed to determine the potential impacts of TA-50 effluent discharges on groundwater quality in the regional zone of saturation just south of Mortandad Canyon. Liquid discharges from TA-50 enter Mortandad Canyon through the small Effluent Canyon tributary, and the Mortandad Canyon stream channel probably serves as a line source of recharge to deeper groundwater systems. Originally, the hydrogeologic work plan and the work plan for Mortandad Canyon called for siting well R-14 on the narrow mesa separating Mortandad Canyon and Ten Site Canyon (LANL 1998, 59599; LANL 1997, 56835). The well site was moved to the floor of Ten Site Canyon due to poor access to the original well location, and because the data quality objectives (DQOs) for this well were modified to include characterization of contaminants in the vadose zone beneath Ten Site Canyon that were the result of TA-35 releases (LANL 2002, 73440). The R-14 site in Ten Site Canyon also provides information about potential contaminants in the regional zone of saturation that could be drawn towards water supply well PM-5, located approximately one mile east-southeast. In addition, the geologic, water-quality, and water-level data from R-14 will be used to update the sitewide hydrologic and geologic conceptual models for the Laboratory.

2.0 PRELIMINARY ACTIVITIES

WGII received contractual authorization to begin administrative preparation tasks on November 14, 2001. One of these tasks included preparing a modification to existing site-specific health and safety plan (SSHASP) No. 273 to include well R-14. WGII also prepared the R-14 waste characterization strategy form (WCSF). The Laboratory prepared the "Sampling and Analysis Plan (SAP) for the Drilling and Testing of LANL Regional Aquifer Characterization Well R-14" (LANL 2002, 73440) to guide field personnel in the execution of R-14 field activities. The host facility, Facility Management Unit (FMU) 80, signed a Facility Tenant Agreement on April 10, 2002, to provide access and security control, safety and health, regulatory, and other work requirements for drilling and completion activities at well R-14.

A readiness review meeting was held on May 14, 2002, to discuss all administrative documents, permits, agreements, and plans pertaining to the R-14 project. The Groundwater Investigations Focus Area project leader signed the readiness review checklist for drill pad construction on May 14, 2002, authorizing the commencement of fieldwork. A second meeting was held May 29, 2002, at which time the readiness review checklist for R-14 drilling was signed.

K. R. Swerdfeger Construction, Inc., was subcontracted by WGII to conduct pre-drilling site preparation. Activities included clearing the site, trimming and removing trees, modifying the access road, grading the drill pad, and constructing a lined cuttings-containment area. Site preparation was conducted and completed from May 16 to 29, 2002.

Initially, the site was cleared of trees and stumps. A bulldozer then was used to cut back an outcrop of rock along the north side of the proposed drill pad to widen and level the site. Parts of the access road were graded and improved. The drill pad was constructed by building up and grading the selected area and compacting the fill. Base-course gravel was distributed and compacted to complete the drill pad. A cuttings-containment area was excavated along the north side of the drill pad and lined with a 6-mil polyethylene liner for storing drilling fluids and cuttings. An 80- by 25-ft secondary-fluids-containment area was constructed to accommodate two 20,000-gal. fluid-storage trailers and provide additional storage capacity for fluids pumped from the containment area. During construction of the secondary containment area, the ground surface was stripped of vegetation and graded and the perimeter was bermed. The area then was lined with 6-mil polyethylene sheeting that overlapped the berms. The cuttings-containment area was fenced and safety barriers were set in place. Office and supply trailers, generators, and safety lighting equipment were moved onto the site prior to Phase I drilling.

3.0 SUMMARY OF DRILLING ACTIVITIES

Dynatec Drilling Company, Inc. (Dynatec) completed drilling activities during May, June, and July 2002. Appendix A compares planned activities outlined in the scope of work with actual work performed. Well R-14 was drilled in two phases, described below in Sections 3.1 and 3.2.

Drilling activities included Phase I coring and Phase II borehole drilling. Phase I involved collecting continuous rock-core samples for geologic characterization and sample splits for chemical analysis. The borehole was cored to a depth of 306 ft below ground surface (bgs), thus achieving the planned coring depth of 300 ft. The objectives of Phase II drilling were to log and collect cuttings at regular intervals for the entire depth of the borehole, collect water samples if possible, and provide a borehole for geophysical measurements and installation of a characterization well. Both air-rotary fluid assist and conventional mud-rotary drilling methods were used to advance the R-14 borehole to a total depth (TD) of 1327 ft bgs.

Equipment and fabrication support for drilling activities were provided by the Field Support Facility. Figure 3.0-1 summarizes site activity information in a chronological graph of drilling and other on-site activities. Figure 3.0-2 summarizes well drilling and installation data and depicts groundwater and geologic conditions encountered.

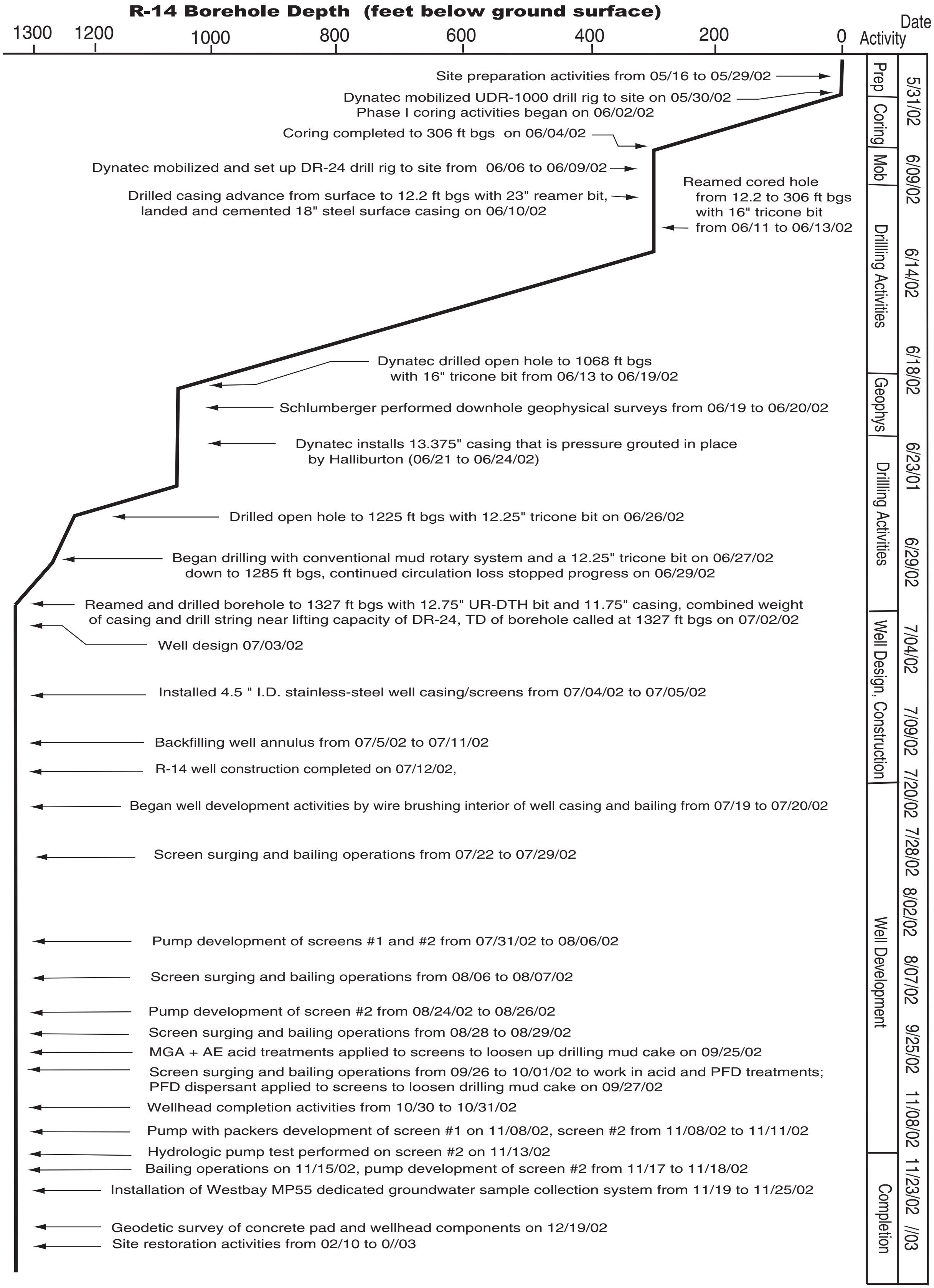


Figure 3.0-1. Operations chronology diagram

Location: In Ten Site Canyon, east of the former radioactive liquid waste and septic treatment facilities at TA-35 .

Survey coordinates (brass marker in NW corner of R-14 cement pad):
x: 1629855 E y: 1768953 N (NAD 83)
z: 7062.1 ft asl (NGVD 29)

Drilling: air rotary core w/ wireline retrieval, conventional mud drilling, casing advance.
R-14 Start date: 06/02/02.
R-14 End date: 07/02/02.

Borehole R-14 drilled to 1327 ft bgs (TD).

Data collection:
Hydrologic properties: Field hydraulic test:
Constant Rate Injection Test on screen #2
Cores/cuttings submitted for geochemical and contaminant characterization: (24)
Groundwater samples submitted for geochem and contaminant characterization: (2)
Geologic properties: (11)
Mineralogy, petrography, and chemistry.

Borehole logs from R-14:
Lithologic: 0-1327 ft
Video (LANL tool): 0-923 ft. and 0-975 ft
Natural gamma (LANL tool): 0-1068 ft and 1046-1325 ft bgs
Schlumberger Logs: 0-12.2 ft (cased), 12.2-1068 ft (open hole): Litho density, Spectral Gamma, Elemental Capture, Thermal/Epithermal Neutron, Combinable Magnetic Resonance, and Natural Gamma.

Contaminants Detected in R-14 Water Samples: none

Well construction:
Drilling Completed: 07/02/02
Contract Geophysics: 06/19/02 - 06/20/02
Well Constructed : 07/04/02 - 07/11/02
Well Developed : 07/19/02 - 11/18/02
Westbay Installed : 11/19/02 - 11/25/02

Casing: 4.5-in I.D. stainless steel with external couplings.

Number of Screens: 2
4.5-in. I D pipe based, s.s. wire-wrapped with 0.010-in. slots.

Screen (perforated pipe interval):
Screen #1 - 1200.6-1233.2 ft. bgs.
Screen #2 - 1286.5-1293.1 ft. bgs.

Well development consisted of wire brushing, bailing, chemical treatments, surging, and pumping.

Groundwater occurrence was determined for R-14 by recognition of first water produced while drilling, by borehole geophysics, and by borehole video. Static water levels were determined after the R-14 borehole was rested.

Groundwater samples collected from packed off screen intervals after well development.

Geologic contacts for R-14 were determined by examination of cuttings and interpretation of borehole video and geophysical logs. Contacts and stratigraphy may be refined by petrographic, geochemical, or mineralogic analysis of geologic samples.

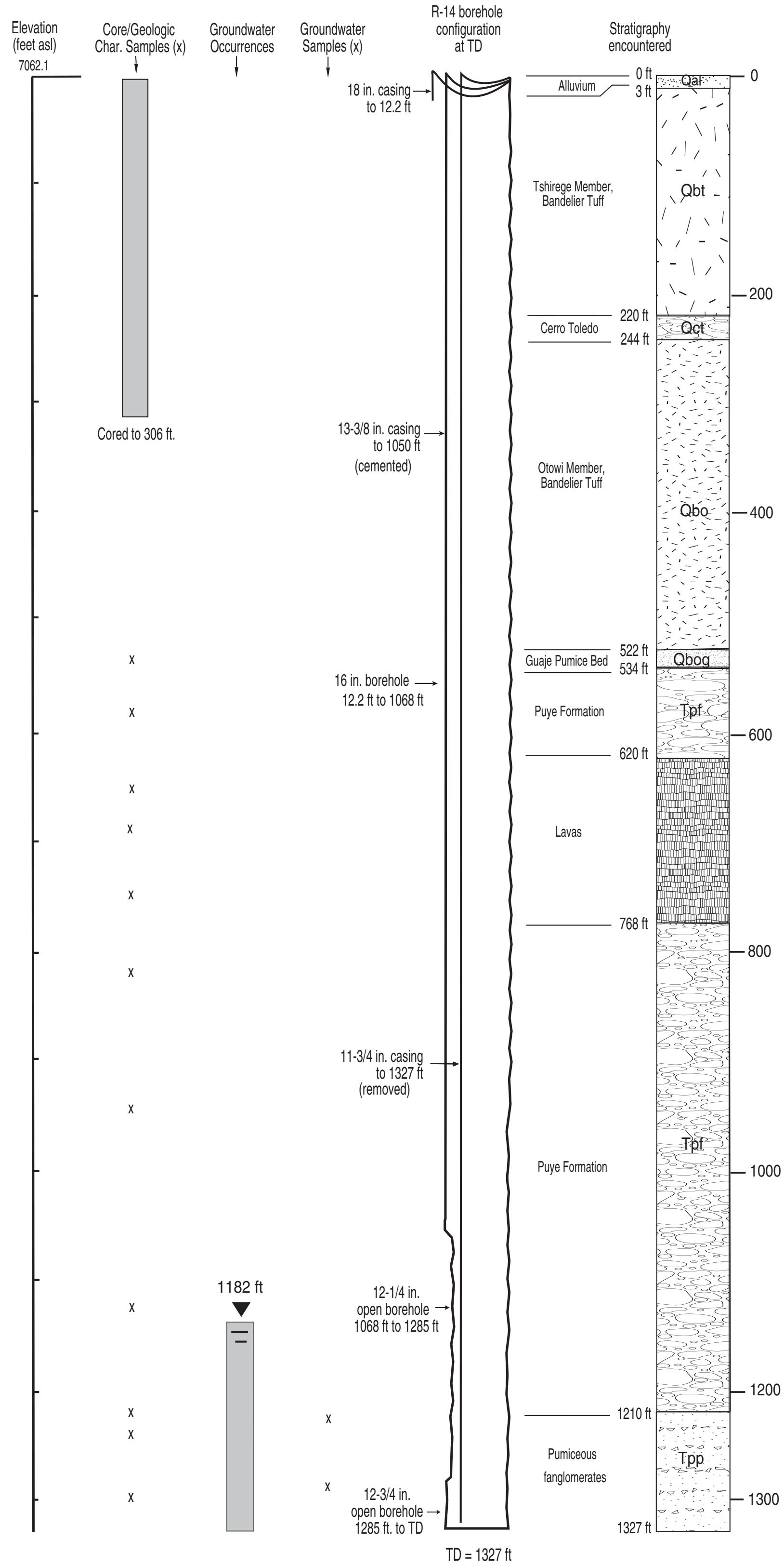


Figure 3.0-2. Well summary data sheet for characterization well R-14

3.1 Phase I Drilling

Phase I drilling activities were conducted from May 30 to June 5, 2002. Dynatec provided a Foremost™ universal drill rig (UDR) 1000 equipped with a wire-line core retrieval system. A 5-ft-long core barrel was used to collect 3-in.-diameter core samples. Dynatec mobilized the UDR-1000 rig and equipment to the site from May 30 to June 1, 2002, and core drilling was completed on June 4, 2002 (Figure 3.0-1). The borehole initially was advanced with a 4-in.-outside-diameter (OD) soft-rock core bit from the surface to 9 ft bgs. To prevent the collapse of alluvial sediments into the borehole during coring operations, a 10-ft section of 6-in.-OD steel surface casing was installed temporarily to a depth of about 9 ft bgs. Coring operations continued through Qbt 2 and 1 of the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, and into the upper part of the Otowi Member of the Bandelier Tuff to a depth of 306 ft bgs. In the Cerro Toledo interval, core recovery problems occurred when rock fragments plugged the core bit. Soft, unconsolidated sediments in the Otowi tuff were also difficult to recover during coring. However, all sample split target intervals were retrieved and collected.

3.2 Phase II Drilling

Phase II drilling started on June 10, 2002, and was completed on July 2, 2002. Dynatec mobilized a Foremost™ dual-rotation (DR) 24 drill rig and equipment, including drill casing, 7-in. reverse circulation (RC) rods, and bit assembly components, to the site on June 6 through 9, 2002. The DR-24 rig was equipped with an air-rotary RC system. Open-hole and casing-advance techniques were employed during air-rotary drilling as determined by changing geologic and drilling conditions. Air-rotary drilling was assisted with a foam mixture that consisted of municipal water mixed with soda ash, QUICK-GEL®, LIQUI-TROL™, and QUICK-FOAM® (Appendix B, which can be found on a CD that is attached to the inside back cover of this report). After encountering the water table, Dynatec equipped the Foremost™ DR-24 drill rig with a conventional mud-rotary drilling system. The system included a mixing tank and pump assembly, a generator to power the mixing unit, a de-sander unit for removing solids from the discharged drilling fluids, and a large auxiliary pump. The fluid mixture used during conventional mud drilling typically consisted of municipal water mixed with QUICK-GEL® and LIQUI-TROL™. Table 3.2-1 summarizes the kinds and amounts of additives used in drilling R-14. Additives were used to improve borehole stability, minimize fluid loss, and facilitate cuttings removal from the borehole. During drilling operations, cuttings samples were collected for geologic characterization at 5-ft intervals from the RC system fluid-discharge hose.

Drilling began by reaming the cored borehole using a 23-in. quadcone reamer bit to advance and land an 18-in. steel surface casing to a depth of 12.2 ft bgs. The casing was cemented in place. From June 11 to June 13, 2002, the corehole was reamed with a 16-in. tricone bit from 12.2 ft bgs to 306 ft bgs. From June 13 to 19, 2002, the borehole was drilled open-hole from 306 ft bgs to 1068 ft bgs with a 16-in. tricone drill bit. Schlumberger, Inc., was mobilized to the site and collected borehole geophysics data on June 19 and 20, 2002. Additional geophysical data were collected using Laboratory geophysical tools.

On June 21, 2002, Dynatec began installing a 13.375-in. conductor casing to 1050 ft bgs, where it was landed on June 22, 2002. Halliburton, Inc., pressure-grouted the surface casing in place with cement, completing installation on June 24, 2002. Dynatec resumed drilling, reaming through approximately 47 ft of residual cement inside the surface casing back down to 1068 ft bgs. The borehole then was drilled open-hole with a 12.25-in. tricone bit into the top of the regional aquifer, stopping at 1225 ft bgs on June 26, 2002, to obtain a static water level, which was measured at 1180.9 ft bgs.

Table 3.2-1
Fluid Additives Used, Characterization Well R-14

Additive	Amount	Unit of Measure
Interval Drilled (0–848 ft)		
Water	22,200	gal.
Bentonite	7.300	lb
Liqui-Trol	4.25	lb
Quick-Foam	201	gal.
Soda ash	18	lb
Interval Drilled (848–1315 ft)		
Water	104,300	gal.
Bentonite	28,250	lb
Liqui-Trol	22	gal.
Quick-Foam	175	gal.
Pac-L	700	lb
N-Seal	1830	lb
Magma Fiber	2160	lb

On June 27, 2002, Dynatec switched to the conventional mud rotary system and continued open-hole drilling with the 12.25-in. bit from 1225 ft bgs to 1285 ft bgs. From June 29 to June 30, 2002, recurring problems with lost fluid circulation around 1285 ft bgs stalled progress. WGII and the Laboratory made the decision to install an 11.75-in. casing, to seal the zones where fluid loss was occurring. On July 2, 2002, Dynatec completed casing installation and reamed through 14 ft of slough back down to 1285 ft bgs. Air-rotary drilling resumed using casing-advance with a 12.75-in. under-reaming down-the-hole (UR-DTH) hammer bit and the 11.75-in. drill casing to 1327 ft bgs. At this time, Dynatec reported that the total combined weight of the drill string and drill casing was approaching the total lifting capacity of the DR-24 drill rig. Consequently, on July 2, 2002, the Laboratory called TD of the borehole at 1327 ft bgs and prepared for well installation.

4.0 SAMPLING AND ANALYSIS OF DRILL CUTTINGS AND GROUNDWATER

Continuous core collection was attempted throughout the entire interval from ground surface to 306 ft bgs according to the R-14 SAP (LANL 2002, 73440) during Phase-I coring operations. A total of 24 samples were analyzed for anions and contaminant profiles. Analytes included anions, moisture content, stable isotopes, radionuclides, and tritium. Results from these analyses are in the QA process and will be reported at a later date. Core segments were placed in sealed plastic sleeves and set in core boxes for curation. Anion/moisture samples were sealed in pre-weighed 8-ounce jars immediately after the core was retrieved. The remaining samples were placed in ziplock bags, then sealed in Protecore® bags. Samples collected for low-level radiation activity were screened and placed in ziplock bags.

Drill cuttings were collected according to the R-14 SAP during Phase II drilling operations. Material was collected from the reverse circulation outlet trough at 5-ft intervals as drilling conditions permitted. A portion of these cuttings was sieved (at >#10 and >#35 mesh) and placed in chip-tray bins along with an unsieved portion. These chip trays were then used to prepare the lithologic logs, which are presented in Appendix C. The remaining cuttings were placed in ziplock bags and set in core boxes for curation.

Eleven sample splits were submitted for mineralogy, petrography, and geochemical analysis prior to curation of material collected during drilling.

Groundwater samples were not collected from the open borehole during drilling because of the adverse impact of drilling mud and additives to the chemistry of groundwater. However, two samples were collected from screened interval at 1200.6–1233.2 and 1286.5–1293.1 ft bgs in the regional aquifer during development activities. The results are reported below.

Geochemistry of Sampled Waters

Groundwater samples were collected and analyzed for a select suite of constituents to investigate the presence of constituents from laboratory releases. Major potential contaminants of concern at R-14 include perchlorate, nitrate, and tritium.

Groundwater samples were collected using a packer/pump assembly that straddled each screen interval and analyzed for inorganic and radionuclide constituents. Filtered water was collected for metals, trace elements, major cations and major anion analysis. Nonfiltered water was collected for stable isotope, tritium, and radiochemical analyses. Filtered samples were passed through a 0.45-µm Gelman cartridge filter. Samples were acidified as needed with analytical-grade nitric acid to a pH of 2.0 or less for metal and major cation analyses. All groundwater samples collected in the field were stored at 4°C until they were analyzed.

Groundwater samples were analyzed by laboratories under contract to LANL under the University of California Los Alamos National Laboratory Statement of Work for Analytical Laboratories (LANL 2000, 71233) and at the Earth and Environmental Science (EES)-6 laboratory. Ion chromatography (IC) was the analytical method for bromide, chloride, fluoride, nitrate + nitrite, oxalate, perchlorate, phosphate, and sulfate. Mercury was analyzed by cold vapor atomic absorption (CVAA). Inductively coupled (argon) plasma emission spectroscopy (ICPES) was used for aluminum, arsenic, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, silver, calcium, magnesium, potassium, silica, sodium, and zinc. Antimony, beryllium, cadmium, lead, thallium, vanadium, and uranium, were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS). Tritium activity in a groundwater sample was determined by electrolytic enrichment at the University of Miami. Americium-241 was analyzed according to HASL-300, cesium-137 by generic gamma spectroscopy, plutonium-238 and plutonium-239 by isotopic plutonium (HASL-300), strontium-90 by beta counting, and uranium-234, uranium-235, and uranium–238 by isotopic uranium (HASL-300). Delta deuterium and oxygen 18/16 ratios were determined at Geochron Laboratory. The precision limits (analytical error) for major ions and trace elements were generally less than ±10% using ICPES and ICPMS.

Results of screening analyses for regional groundwater samples collected from the Puye Formation in R-14 are provided in Table 4.1-1. Based on the analytical results for two samples, it appears that contamination from Laboratory discharges is not present in the regional aquifer at this well site.

5.0 BOREHOLE GEOPHYSICS

WGII (using Laboratory tools) and Schlumberger performed borehole-logging operations at well R-14. Table 5.0-1 lists the logging surveys performed.

Table 4.1-1
Hydrochemistry of Regional Aquifer Samples at R-14

Depth (ft)	**1200.6–1233.2**	**1286.5–1293.1**
Geologic Unit	**Puye Formation**	**Puye Formation**
Analytical Laboratory	**Contract and EES-6 Laboratories**	**Contract and EES-6 Laboratories**
Date Sampled	**11/08/02**	**11/11/02**
Inorganic (filtered)		
Alkalinity (lab; mg $CaCO_3$/L)	58.5	58
Conductivity (field; µS/cm)	132.2	129.9
pH (field)	6.90	6.67
Temperature (field; ^{o}C)	22.9	23.2
Turbidity (field; NTU)	0.69	0.36
Al (mg/L)	[0.030], U	[0.1], U
Sb (mg/L)	[0.002],U	[0.002],U
As (mg/L)	[0.005], U	[0.005], U
Ba (mg/L)	0.036	0.040
Be (mg/L)	[0.0002], U	[0.0002], U
B (mg/L)	0.018	0.008
Br (mg/L)	0.04	[0.01], U
Cd (mg/L)	[0.001], U	[0.001], U
Ca (mg/L)	9.9	9.9
Cl (mg/L)	1.92	1.81
ClO_4 (mg/L)	[0.002], U	[0.002], U
ClO_3 (mg/L)	[0.02], U	[0.02], U
Cr (mg/L)	[0.001], U	[0.002], U
Co (mg/L)	[0.002], U	[0.001], U
Cu (mg/L)	[0.005], U	[0.005], U
F (mg/L)	0.22	0.19
Fe (mg/L)	0.1	0.09
Pb (mg/L)	0.0001, J	0.0001, J
Mg (mg/L)	3.1	3.1
Mn (mg/L)	0.36	0.33
Mo (mg/L)	0.0018	0.0016
Hg (mg/L)	[0.00005], U	[0.00006], U
Ni (mg/L)	0.003, J	[0.002], U
NO_3 (mg/L; as N)	[0.002], U	0.05
NO_2 (mg/L; as N)	[0.002], U	[0.002], U
TKN (mg/L)	0.72	0.33
C_2O_4 (mg/L) (oxalate)	[0.02], U	[0.02], U
P (mg/L)	0.26	0.24
K (mg/L)	1.9	1.9

Table 4.1-1 (continued)

Depth (ft)	**1200.6–1233.2**	**1286.5–1293.1**
Geologic Unit	**Puye Formation**	**Puye Formation**
Analytical Laboratory	**Contract and EES-6 Laboratories**	**Contract and EES-6 Laboratories**
Date Sampled	**11/08/02**	**11/11/02**
Inorganic (filtered) (continued)		
Se (mg/L)	[0.005], U	[0.005], U
Ag (mg/L)	[0.005], U	[0.005], U
Na (mg/L)	13	12.9
SiO_2 (mg/L)	77.3	77.9
SO_4 (mg/L)	2.28	2.48
Tl (mg/L)	[0.0005], U	[0.0005], U
TOC (mg/L)	1.86	1.95
U (mg/L)	0.001	0.001
V (mg/L)	0.009	0.009
Zn (mg/L)	0.41	0.36
δD (permil)	-82	-83
$\delta^{18}O$ (permil)	-11.2	-10.9
Radionuclides (nonfiltered)		
Am^{241} (pCi/L) (nonfiltered)	[0.007], U	[0.0098], U
Cs^{137} (pCi/L) (nonfiltered)	[-1.05], U	[-0.003], U
Pu^{238} (pCi/L) (nonfiltered)	[0.008], U	[0.002], U
Pu^{239} (pCi/L) (nonfiltered)	[-0.031], U	[0.011], U
Sr^{90} (pCi/L) (nonfiltered)	[0.047], U	[-0.2], U
Tritium (pCi/L) (nonfiltered)	[0.26], U	[0.22], U
U^{234} (pCi/L) (nonfiltered)	0.64	0.66
U^{235} (pCi/L) (nonfiltered)	[0.025], U	0.033
U^{238} (pCi/L) (nonfiltered)	0.41	0.38

Note: U = not detected. Dash = not analyzed. TOC = total organic carbon. J = analyte is classified as “detected” but the reported concentration value is expected to be more uncertain than usual.

Table 5.0-1
Borehole and Well Logging Surveys, Characterization Well R-14

Surveyor	Date	Method	Cased Footage	Open-Hole Interval (ft bgs)	Remarks
Schlumberger	June 19 to 20, 2002	Logging Suite[a]	0–12.2	12.2–1068	Schlumberger borehole logging conducted in uncased R-14 borehole prior to installing 13.375-in. surface casing.
LANL/WGII	June 20, 2002	Video, natural gamma and induction tools	0–12.2	12.2–1068	LANL borehole logging conducted in uncased R-14 borehole prior to installing 13.375-in. surface casing.
LANL/WGII	July 3, 2002	Natural gamma	0–1327	NA[b]	Survey conducted to gather data for well design after reaching TD.
LANL/WGII	July 5, 2002	Video	0–1316	NA	Survey conducted to document and verify integrity of well construction.
LANL/WGII	November 14, 2002	Video	0–1316	NA	Survey conducted to document and verify well interior condition prior to Westbay™ installation.

[a] The Schlumberger suite of borehole logging surveys included combinable magnetic resonance, triple detector lithodensity, epithermal compensated neutron log, elemental capture spectroscopy, and spectral and natural gamma-ray spectroscopy.
[b] NA = Not applicable.

5.1 Geophysical Logging Using Laboratory Tools

Between June 20 and November 14, 2002, natural gamma, induction, and video camera logs were run in borehole R-14 by WGII using down-hole tools provided by the Laboratory. The gamma and induction logs were collected to provide lithologic and stratigraphic information that complement data gathered from core and cuttings. Video logs were performed as a quality assurance procedure during well construction and development. Two natural gamma logs were run by the Laboratory and WGII. Natural gamma logs have proven successful in discriminating between geologic units that contain varying concentrations of uranium, thorium, and potassium. The gamma tool also is used for verifying backfill placement. The first gamma log was performed inside the 18-in. surface casing from the surface to 12.2 ft bgs and in the open hole from 12.2 to 1068 ft bgs prior to installation of the 13.375-in. casing. An induction log was run in the borehole concurrently with the first Laboratory gamma log. The second natural gamma log was run inside the 18-in. surface casing from the surface to 12.2 ft bgs, in the 13.375-in. conductor casing from surface to 1050 ft bgs, and in the 11.75-in. drill casing from surface to borehole TD at 1327 ft bgs. Measurements of natural gamma activity were obtained every 0.1 ft as the logging tool was raised in the hole at a rate of about 15 ft/min.

Table 5.0-1 summarizes borehole and well logging surveys performed. The borehole video log (Appendix D) can be found on a CD that is attached to the inside back cover of this report.

5.2 Schlumberger Geophysical Logging

Schlumberger conducted borehole geophysical logging on June 19 through June 20, 2002, at R-14. A suite of logging surveys was run inside the 18-in. casing from surface to 12.2 ft bgs and open-hole from 12.2 to 1068 ft bgs.

The primary purpose of the Schlumberger logging work was to characterize conditions in the hydrogeologic units penetrated by the borehole, with an emphasis on determining moisture distribution and flow capacity, identifying perched and regional groundwater zones, and obtaining lithologic and stratigraphic data.

The Schlumberger suite of geophysical logging tools included the following:

- Combinable Magnetic Resonance (CMR™). Measures the nuclear magnetic resonance response to the formation, evaluates total and effective water-filled porosity of the shallow formation, and estimates pore size distribution and hydraulic conductivity.
- Triple Detector Litho-Density (TLD™). Measures formation bulk density related to porosity, photoelectric effects related to lithology, and borehole diameter using a single-arm caliper.
- Natural Gamma Spectroscopy (NGS™): Measures gross natural and spectral gamma-ray activity (including potassium, thorium, and uranium concentrations) in open- and cased-hole conditions to help characterize geology and lithology.
- Elemental Capture Spectroscopy (ECS™). Measures elemental weight concentrations of a variety of elements to characterize formation mineralogy, lithology, and water content.
- Compensated Neutron Tool, Model G (CNTG™). Measures volumetric water content beyond the casing to evaluate formation porosity and moisture content.

Additionally, a calibrated natural gamma tool was used and gross natural gamma-ray activity was recorded with every logging method (except NGS™) to correlate depth intervals between each survey.

The Schlumberger geophysical logs (compiled as a montage) and logging summary report for borehole R-14 are presented in Appendix E, which can be found on a CD that is attached to the inside back cover of this report.

6.0 LITHOLOGY AND HYDROGEOLOGY

A preliminary assessment of the hydrogeologic features encountered during drilling operations at R-14 is presented below. Included is a brief description of the geologic units identified during characterization of cuttings. Discussion of groundwater occurrences is based on drilling evidence and geophysical logging data.

6.1 Stratigraphy and Lithologic Logging

Lithologic descriptions are based on core samples and cuttings samples collected during drilling operations. Rock units and stratigraphic relationships were determined primarily from data collected by visual examination of drill cuttings samples and should be considered preliminary. The Laboratory may revise such interpretations after future detailed analysis of petrographic, geochemical, mineralogical, and geophysical logging data. A generalized stratigraphic column is shown in the well summary sheet for R-14 (Figure 3.0-2).

Fill (0 to 3.5 ft bgs)

Unconsolidated materials, including base-course gravel and reworked materials from the Bandelier Tuff used to construct the R-14 drill pad were noted in the interval from 0 to 3.5 ft bgs.

Tshirege Member of the Bandelier Tuff, Qbt 2 (3.5 to 80 ft bgs)

Qbt 2 of the Tshirege Member of the Bandelier Tuff, intersected from 3.5 to 80 ft bgs, is represented by rhyolite ash-flow tuff composed of pumice lapilli in a matrix of quartz and sanidine phenocrysts and abundant (up to 80% by volume) ash. Pumices, generally 1 to 2 cm long, are devitrified and typically flattened. Matrix ash is crystalline and devitrified. The unit exhibits a moderate degree of welding in the upper part and becomes less welded in its lower section.

Tshirege Member of the Bandelier Tuff, Qbt 1 (80 to 220 ft bgs)

Qbt 1v and Qbt 1g of the Tshirege Member of the Bandelier Tuff were recognized in R-14 between 80 and 220 ft bgs. They are discussed herein as a single, undivided rock unit. This rhyolite ash-flow tuff unit is composed of pumice lapilli (up to 4 cm long) and quartz and sanidine phenocrysts in a matrix of ash. The upper part of this interval is poorly welded to nonwelded and contains crystallized (devitrified) pumices and devitrified ash. In contrast, the lower part of the interval exhibits distinctive glassy, fibrous pumices and matrix ash with abundant glass shards, indicating its vitric nature relative to the upper section.

Cerro Toledo Interval (220 to 244 ft bgs)

The Cerro Toledo interval, typically made up of rhyolite tephra and volcaniclastic sediments in the investigation area, underlies the Tshirege Member in the interval from 220 to 244 ft bgs. Poor core recovery was experienced in this section. Examination of the limited sample material produced indicates the Cerro Toledo is made up locally of dacitic gravels and tuffaceous sand with minor pumice.

Otowi Member of the Bandelier Tuff (244 to 534 ft bgs), including the Guaje Pumice Bed (522 to 534 ft bgs)

The Otowi Member of the Bandelier Tuff, composed of rhyolite ash flow tuffs, was intersected in the 278-ft-thick interval from 244 to 522 ft bgs. Core and drill cuttings indicate that this unit is composed of fibrous glassy pumice, quartz and sanidine crystals, volcanic xenoliths, and vitric ash. Pumice lapilli in the upper part of the Otowi Member locally are yellowish brown in color. Chip samples typically contain 40% to 70% by volume dacite and andesite lithics that represent inclusions formerly enclosed in the tuff matrix. The lack of preserved indurated ash matrix in chip samples suggests this tuff interval is poorly welded to nonwelded.

Borehole R-14 intersected the Guaje Pumice Bed immediately below the Otowi Member of the Bandelier Tuff in the interval from 522 to 534 ft bgs. Drill cuttings indicate that the Guaje Pumice Bed consists of fibrous, vitric, rhyolitic pumice, quartz and sanidine crystals, and abundant dacite and andesite lithic fragments.

Upper Puye Formation (534 to 620 ft bgs)

The first of two fanglomerate sequences that represent the Pliocene Puye Formation at R-14 occurs in the interval from 534 to 620 ft bgs. Cuttings in this interval are finely ground by the effects of drilling. Chips appear to be composed exclusively of gray, aphanitic, aphyric to sparsely porphyritic dacite.

Unassigned Dacitic Lavas (620 to 768 ft bgs)

R-14 encountered a sequence of dacite flows in the interval from 620 to 768 ft bgs. Dacitic volcanics were not expected in this borehole. These volcanic rocks have not yet been classified, and it is not certain whether they should be grouped with dacites and andesites of the Tschicoma Formation or with the generally more mafic volcanics of the Cerros del Rio basalt. Therefore, dacites in this interval are not assigned to a rock unit and origin.

Dacites in the above interval are characterized as reddish brown, massive, aphyric, and aphanitic to sparely porphyritic with a finely crystalline groundmass. Fine-grained phenocrysts of pyroxene, plagioclase, and possibly quartz make up no more than 5% by volume.

Lower Puye Formation (768 to 1210 ft bgs) and Pumiceous Fanglomerates (1210 to 1327 ft bgs)

A sequence of fanglomerate deposits that forms a stratigraphically lower section of the Puye Formation was penetrated from 768 to 1210 ft bgs. Cuttings from the upper part of this interval (768 to 1068 ft bgs) contain abundant dacite and chips of gray clay. Sericite and/or clay alteration of dacite generally increases with depth. Cuttings from 1068 to 1210 ft bgs represent fine-to-coarse Puye sediments that contain a variety of volcanic clasts, predominantly porphyritic dacite with lesser latite, rhyolite, and minor pumice. The fanglomerates from 1210 ft bgs to the base of the sequence are pumice-bearing. Cuttings from this lowermost interval contain a significantly greater percentage of pumice than exhibited elsewhere in the sequence and also contain quartz and microcline from Precambrian sources. Stratigraphic assignment of the pumiceous sequence is uncertain.

6.2 Groundwater Occurrence and Characteristics

Well R-14 was expected to encounter both perched groundwater zones and regional aquifer saturation (Appendix A). Two potential zones of perched saturation were projected between 575 to 608 bgs (the anticipated depth of the Guaje Pumice Bed) and between 737 to 881 ft bgs (near the base of the expected Cerros del Rio basalt). Any perched water in small amounts could not be observed during fluid-assisted open-hole drilling operations because drilling with foam substantially reduced the ability to detect perched groundwater zones. The borehole video log confirmed that no perched horizons were present.

The regional water table was intersected in lower Puye fanglomerate sediments and measured at approximately 1182 ft bgs on June 26, 2002. Drilling beyond this depth switched to conventional mud-rotary techniques; thus it was not possible to make any observation of groundwater characteristics. No water samples were collected for chemical analysis during drilling operations.

7.0 WELL DESIGN AND CONSTRUCTION

7.1 Well Design

The well design for R-14 was completed jointly by the Laboratory and WGII, in consultation with the US Department of Energy (DOE), and the New Mexico Environment Department (NMED). Geophysical logs, video logs, borehole geologic samples, water-level data, field water-quality data, and drillers' observations were reviewed by the Groundwater Investigations Team to plan screen placement intervals for the well. The well design specified two screens to monitor the distribution and concentration of potential contaminants in the regional aquifer. The number and placement of screens were designed to meet the following criteria:

- to monitor near the top of the regional zone of saturation, and
- to monitor a deeper productive zone within the regional aquifer.

Productive intermediate perched groundwater zones were not encountered during drilling; therefore, no screens were placed above the regional aquifer. The planned and actual screen depths are given in Table 7.1-1.

Table 7.1-1
Summary of Well Screen Information, Characterization Well R-14

Screen	Planned Depth (ft)	Actual Depth (ft)	Geologic/Hydrologic Setting
1	1201.6–1234.6	1200.6–1233.2	Near top of regional zone of saturation in the Puye Formation
2	1286.8–1293.6	1286.5–1293.1	Deeper zone of the regional aquifer in pumiceous sediments

7.2 Well Construction

The well casing and pipe-based screens were manufactured using 4.5-in. inner diameter (ID)/5.0-in. OD, type 304, stainless steel fabricated to meet American Society for Testing and Materials (ASTM) 1994 A554 standards. The external couplings were also of type 304 stainless steel fabricated to meet ASTM standard A312, which exceed the tensile strength of the threaded casing ends. The pipe-based screens were fabricated by Weatherford Well Screens (Johnson Screens, Inc.) using 10-ft sections of blank well casing. A series of 0.5-in.-diameter holes were drilled in the pipe and then stainless steel wire wrap (0.010-in. spacing) and welded over the perforations. The final OD of the screens was 5.5 in.

The stainless steel well components were decontaminated at the well site using a high-pressure steam cleaner and scrub brushes. To centralize the well in the borehole, stainless steel centralizers were installed above and below each screen, and in several locations above the zone of regional saturation. All backfill materials were emplaced in the well annulus through a tremie pipe. An as-built drawing of the completed well is provided in Figure 7.2-1.

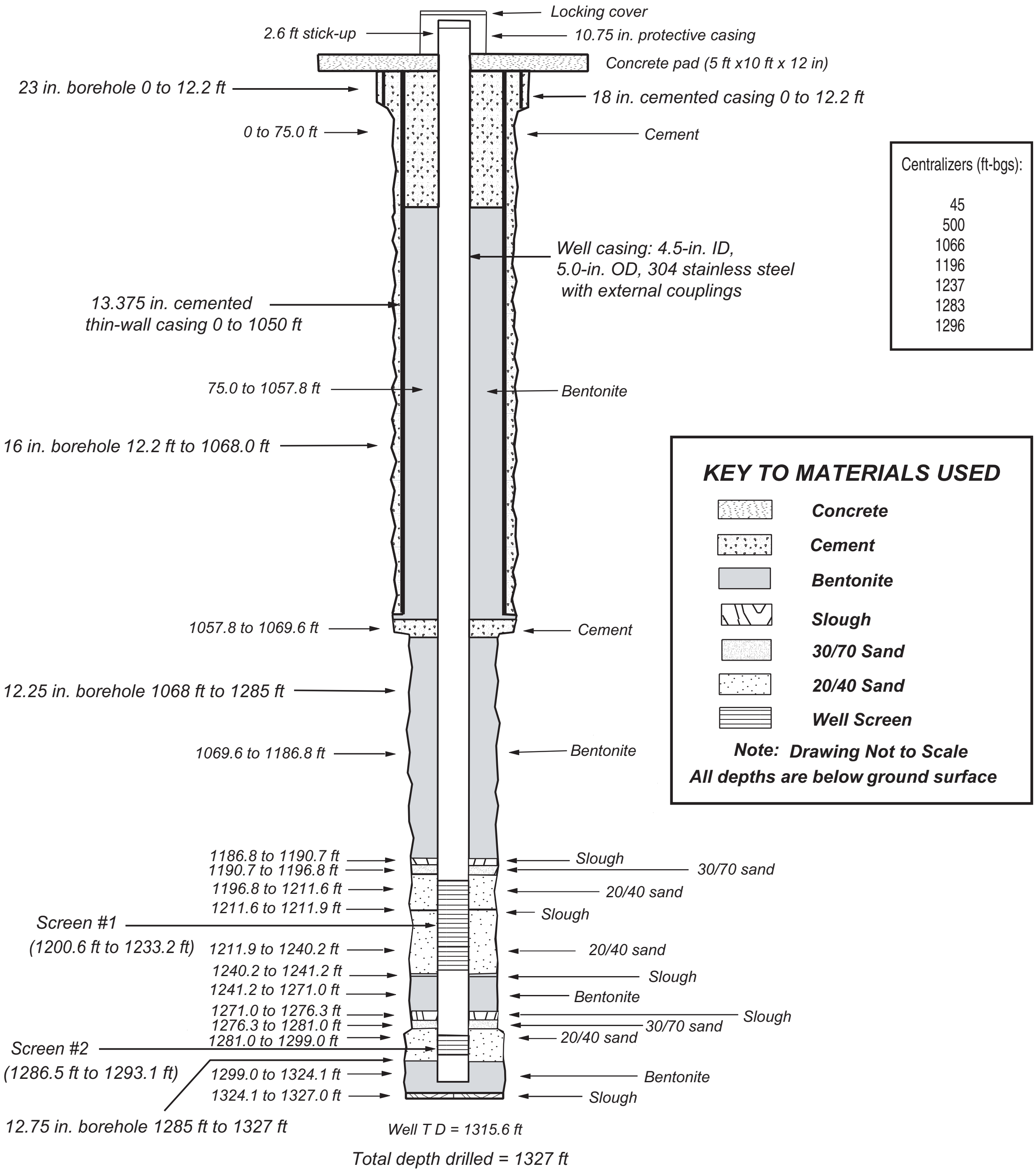
7.2.1 Well Installation

Well installation consisted of connecting stainless steel well screens and casing joints by means of threaded external couplers as specified in the well design. The base of the well was set at 1315.6 ft bgs. Dynatec installed the well casing from July 4 to 5, 2002 (Figure 3.0-1). Figure 7.2-1 illustrates the final well configuration and indicates the depths of the various well components from ground surface to TD.

7.2.2 Annular Fill Placement

A steel tremie pipe was used to deliver annular materials at the depth intervals specified in the well design. The bottom of the borehole was measured with a tag line at 1324.1 ft bgs before fill material was introduced into the annulus. Dynatec installed the annular fill material from July 5 through July 11, 2002 (Figure 3.0-1). Filter packs across screened intervals consisted of silica sand materials mixed with municipal water and placed in the annulus as a fluid slurry. Bentonite materials were placed between screened intervals to seal the annular space and prevent interaction between water-bearing zones. Portland cement (mixed at a ratio of 5 gal. of water per bag of cement) was used to provide a foundation for the annular fill and for wellhead protection in the upper 75 ft of the borehole and behind the casing to 1050 ft. Approximately 13,631 gal. municipal water were used during annular fill material placement.

Table 7.2-1 lists the annular fill materials used. The final configuration of the annular materials is also illustrated in Figure 7.2-1.



Note: 1. Each screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.

2. The intervals of slough consist of sands and gravel of the Puye Formation.

3. Westbay multiport sampling system (MP-55) casing not shown.

4. Pipe-based screen: 4.5-in. ID, 5.563-in. OD,304 stainless steel with s.s. wire wrap; 0.010-in. slot.

5. Well sump interval: 1293.1 to 1315.6 ft

Figure 7.2-1. As built well configuration diagram, characterization well R-14

Table 7.2-1
Annular Fill Materials, Characterization Well R-14

Material	Use/Function	Amount	Unit*
20/40 sand (medium-grained)	To pack screened intervals	109.5	Bag
30/70 sand (fine grained)	To separate screen packs from bentonite or cement from bentonite	30	Bag
Benseal® bentonite (granular bentonite)	Produces slurry when mixed with water	2	Bag
Pelplug® bentonite pellets (0.25-in. by 0.375-in. refined elliptical pellets)	To provide borehole annular seal below water table	403	Bucket
Quick-Grout® bentonite grout (powdered bentonite)	To provide annular seal between casing strings	132	Bag
Portland® cement (mixed with municipal water at ratio of 5 gal. water for each bag of cement)	To provide annular support and surface seal on upper 100 ft of borehole	57	Bag

*Sand bag = 50 lb ea; bentonite bag/bucket = 50 lb ea; cement bag = 94 lb ea.

8.0 WELL DEVELOPMENT AND HYDROLOGIC TESTING

Dynatec conducted well development and hydrologic testing at R-14 from July 19 to November 18, 2002 (Figure 3.0-1). Development activities included preliminary bailing, wire-brushing, surging and bailing, and pumping. Baroid chemical additives were used to aid in wall-cake breakdown and to remove drilling mud wall cake (see Appendix B). Hydrologic injection tests were run after the well was developed.

8.1 Well Development

Well development at R-14 was accomplished by wire-brushing the well interior, bailing, surging, and pumping. After the well's interior was brushed, each screen was surged and bailed to flush particulate matter from the filter pack and formation. A submersible pump and packer system were then lowered to both screens and on/off cyclic pumping conducted to remove any remaining fines from the screened intervals. Criteria for R-14 well development were based on selected field water-quality parameters (turbidity, specific conductance, pH, and temperature) measured in groundwater samples. To monitor progress during each development procedure, groundwater samples were collected periodically, and time-series parameter measurements were recorded. One objective of well development was to remove suspended sediment from the water until turbidity (measured in nephelometric turbidity units [NTU]) decreased to a value of less than 5 NTU for three consecutive samples. Similarly, other measured parameters were required to stabilize before development procedures terminated. When these criteria were met, the well was declared developed.

Well development began on July 19, 2002, by bailing out the well sump to remove debris and sediment. The well casing and screens then were cleaned using a wire-brush system, and the sump was bailed again. Turbidity measurements ranged from 202 to 158 NTU, and 2025 gal. of water were bailed during this procedure (Table 8.1-1).

Surging techniques were employed across screens 1 and 2 using a wireline-controlled, weighted surge block for rapid upward strokes to retrieve fines and wall-cake materials from the screen filter pack and surrounding formation. The well screens were surged repeatedly, and then bailed and pumped. An estimated 7055 gal. of well water were purged from the well during the surge/bail procedure. Water turbidity measured 158 NTU at the beginning and 160 NTU at the end (Table 8.1-1).

Table 8.1-1
Development of R-14

Method	Water Produced (gal.)	Parameters[a]			
		pH	Temperature (°C)	Specific Conductance (μS/cm)[b]	Turbidity (NTU)
Preliminary bailing/wire brushing	2025	8.0–8.0	24.0–22.0	441–207	202–158
Surge/bail/pump	7055	7.9–7.7	22.1–20.1	223–150	158–4
Pump screen 1 w/packers	2110	7.7–7.6	19.1–22.6	158–139	6–1
Pump screen 2 w/packers	46,930	7.5–7.4	22.1–23.4	195–160	6–218
Surge/bail	870	7.5–7.7	23.3–23.1	247–342	>1000–>1000
Pump screen 2 w/out packers	9200	8.0–7.8	22.8–23.9	379–173	>1000–<1
Surge/bail	130	6.9–7.7	21.5–23.4	NM[c]	>1000–>1000
Chemical treatment (310 gal. in screen 1, 90 gal. in screen 2)	+400	—[d]	—	—	—
Surge/bail	290	3–4	NM	NM	NM
Chemical treatment; add 400 gal. PFD to well	+400	—	—	—	—
Surge/bail	1180	3.4–3.7	21.9–21.0	2249–1132	126–141
Pumping screen 2 w/packers	126,830	5.7–6.7	23.2–23.2	385–130	83–<1
Pumping screen 1w/packers	3500	7.0–6.9	22.2–22.9	134–132	<1–<1
TOTAL	205,010				

[a] Parameters presented as value at beginning followed by value at end of development method.

[b] Specific conductance reported in microsiemens per centimeter.

[c] NM = Not measured.

[d] Dash indicates no samples collected during chemical treatment.

Pump development of the R-14 well began on July 31, 2002. A 10-horsepower (hp) submersible pump was lowered to each screen with an inflatable packer system deployed with one packer above and one packer below the screened interval as appropriate to isolate the water-bearing zone. On/off cyclic pumping was conducted with nominal 30-min periods of nonpumping to allow the water level to recover in the well. Water samples were collected at frequent intervals to monitor parameters. Development pumping was first applied to screen 1. An estimated 2110 gal. of water were pumped from screen 1, and turbidity measurements were consistently near or below the acceptable well development criterion (5 NTU) throughout this pumping procedure (Table 8.1-1). An estimated 46,930 gal. of water were pumped from screen 2, with final turbidity reaching 218 NTU.

To accelerate development progress and dislodge particulates in the filter pack and formation, surge/bail procedures were attempted again at screens 1 and 2 on August 6 and 7, 2002. Development activities at R-14 were suspended for approximately two weeks. When pumping at screen 2 continued on August 24, 2002, the well produced a grayish-colored water. Surge-and-bail methods resumed August 28 through 29, 2002. Water bailed at this stage was extremely turbid and black in color. After Baroid representatives were consulted, chemical treatments were applied to the well screens to enhance well development. On September 25, 2002, the first chemical treatment of the impacted well screens was carried out. A solution consisting of 30 lb AQUA-CLEAR™-MGA (modified granular acid) and 3 gal. AQUA-CLEAR™-AE (acid enhancer) per 100 gal. of municipal water was mixed on the site. A tremie pipe was used to inject 310 gal. of the solution into the screen 1 area and 90 gal. into the screen 2 area. Surge-and-bail procedures then were carried out at both screens from September 26 to October 1, 2002. During this procedure, an additional chemical treatment (a dispersant called PFD) was applied to the well on September 27, 2002. The solution consisted of 1.5 gal. PFD mixed with 400 gal. of municipal water. As water was withdrawn from the well, the pH was monitored with paper test strips. When the pH value returned to a range of 5.0 to 6.0, the well could be pumped.

From October 6 to October 10, 2002, pumping was resumed at screen 2. As pump development progressed, parameter values for specific conductance and pH stabilized, and turbidity readings declined to NTU values of less than one. Additional pumping from screens 1 and 2 was performed from November 8 to November 11, 2002, using inflatable packers above and below the screens to isolate the water-bearing intervals. Development pumping continued until an additional 136,690 gal. had been withdrawn (Table 8.1-1) and the ranges of monitoring measurements for all parameters were consistently acceptable.

8.2 Hydrologic Testing

On November 13, 2002, the Laboratory conducted three hydrologic tests across screen 2. Screen 1 straddles a geologic contact and was not tested because the unit to which results would apply was uncertain. Thus, testing focused on screen 2, which lies wholly within the pumiceous Puye. Three straddle-packer/injection tests were conducted: two short tests (1 min each with different injection rates) and one test of longer duration at a higher injection rate. After testing, approximately 4750 gal. of water were purged from the well. The short tests were analyzed by slug-test methods and the longer test was analyzed by pumping-test methods. The results of the injection tests will be presented in a separate report entitled “Hydrologic Tests at Characterization Well R-14” to be released later this year.

8.3 Installation of Westbay™ Monitoring System

A Westbay™ sampling system was installed inside the stainless steel well casing after development procedures were completed. Installation work was performed from November 18 to 25, 2002. The base of the multiport casing was set at 1311 ft bgs. The system is set in place using a series of packers inflated with de-ionized water and positioned to target each well screen with a set of valved ports. The R-14 system contains seven ports to inflate and test eight packers. Screen 1 is accessed by three measurement ports and screen 2 by two measurement ports. Both measurement zones also contain a pumping port.

Quarterly sampling of Westbay™-equipped wells will be conducted using a Laboratory-owned sampling trailer outfitted with the MOSDAX sampling system (controller, sampler probe, and sample bottle train) and a motorized winch-and boom-system. The Westbay™ summary MP casing log provides details of the installed system (Appendix F, which can be found on a CD that is attached to the inside back cover of this report).

9.0 WELLHEAD COMPLETION AND SITE RESTORATION

When operational tests were completed on the installed sampling system, the protective casing height was adjusted to accommodate a locking cap over the Westbay™ installation. Finish work commenced on the wellhead area, well components were surveyed, and the site underwent final cleanup and restoration.

9.1 Wellhead Completion

The surface completion for well R-14 involved construction of a reinforced (5000 psi) concrete pad, 5 ft wide by 10 ft long by 12 in. thick, around the well casing to ensure the long-term structural integrity of the well components (Figure 9.1-1). The concrete pad was poured on October 30, 2002. A brass survey pin was installed in the northwest corner of the concrete pad. A 10.75-in.-diameter steel casing with locking lid protects the well riser. Four 4-in.-diameter steel bollards were placed next to each side of the pad. The bollard on the west side can be removed to provide access to the well for sampling and maintenance. The pad was designed to be slightly elevated, with base coarse graded around the pad to allow drainage.

9.2 Geodetic Survey

Southwest Mountain Surveys, Inc. (NMPLS #6998) conducted a geodetic survey of well R-14 on December 19, 2002, using a global positioning satellite (GPS) system. The GPS system utilizes National Geodetic Vertical Datum (NGS) of 99/96 for vertical computations and the datum for the horizontal control network is North American Datum 1983 (NAD 83).

The survey located the brass cap monument in the northwest corner of the concrete pad and measured elevations to the top of the steel exterior protective casing, top of the Westbay™ cap, and top of the Westbay™ plate at R-14 (Table 9.2-1). The coordinates shown are in New Mexico State Plane coordinates, Central Zone (NAD 83) expressed in feet. To be consistent with current Laboratory standards, elevations are expressed in feet above mean sea level and referenced to the National Geodetic Vertical Datum of 1929 (NVGD29).

9.3 Site Restoration

Site restoration activities at R-14 were conducted from February 10 to March 13, 2003 (Figure 3.0-1). Waste management activities were performed before and during restoration. Waste materials were removed from the site, following the WCSF. Drilling-generated media, including drilling fluids, cuttings, and development water, were sampled for contaminant analysis. These data were reviewed by the Laboratory and NMED (Appendix G). The drill cuttings were used to help backfill the containment area and the drilling fluids and development water were applied downgradient of the site in accordance with the provisions of the Notification of Intent (NOI). The waste streams from spill clean up included petroleum-contaminated soils and absorbent materials used to clean up minor spills. After the Laboratory approved the waste profile forms, the waste streams were disposed of as New Mexico Special Waste. The drill site area was recontoured by K. R. Swerdfeger Construction, Inc., to conform to the surrounding topography. Before the area was recontoured, the cuttings-containment area was excavated and the plastic lining was removed. The containment basin and water-tank storage areas then were backfilled with dirt that had been bermed during pad construction and the area was regraded. Base-course gravel was also regraded and compacted across the site to form a smaller pad. In addition, a chipper was moved to the site to chip slash piles accumulated during tree removal procedures related to drill pad construction. The slash-pile chips were used to mulch reseeded areas of the site.

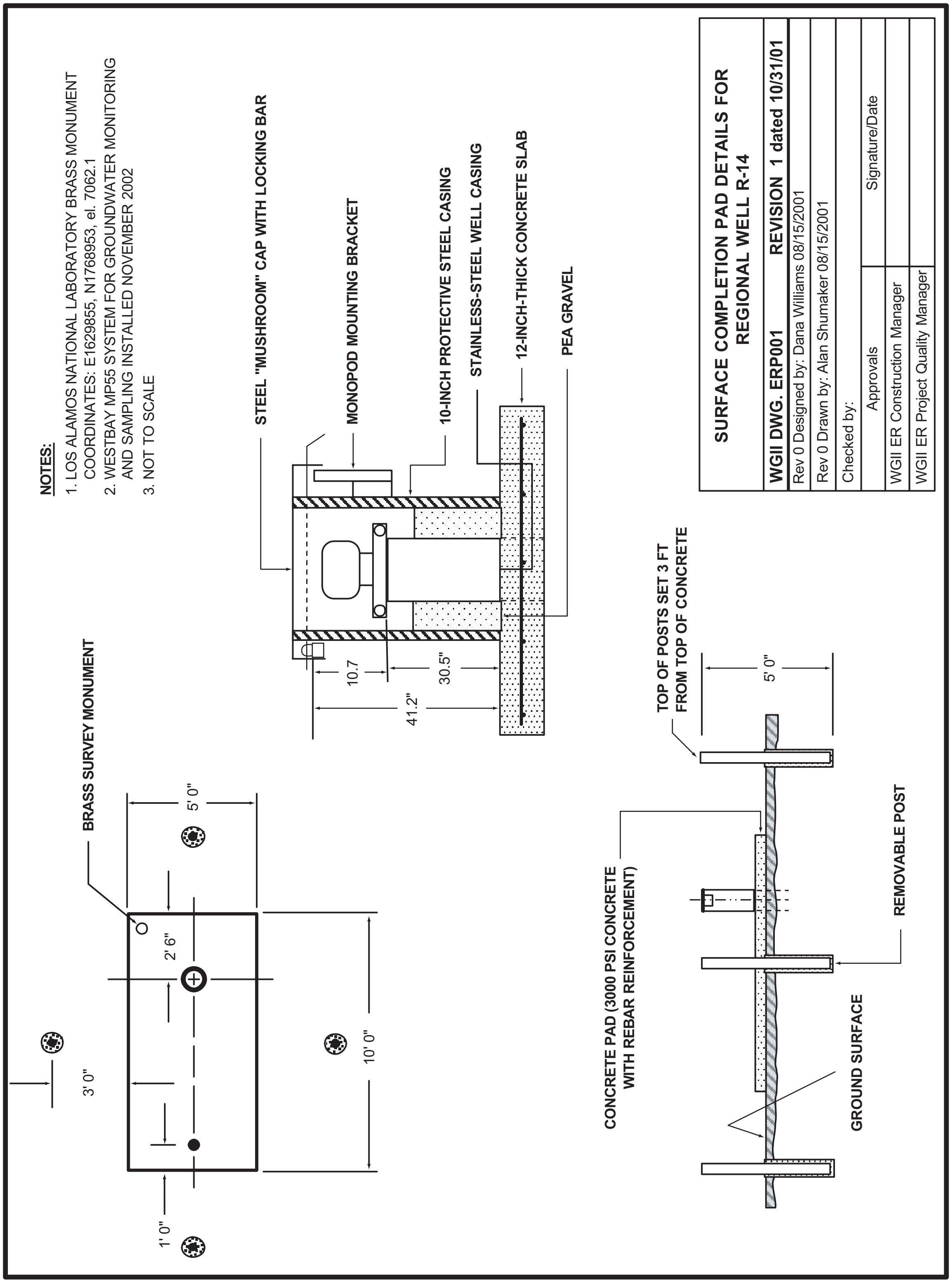


Figure 9.1-1. Surface completion configuration diagram

Table 9.2-1
Geodetic Data for Well R-14

Description	East	North	Elevation
Top of steel protective casing (north edge)	1629856.31	1768951.35	7065.60
Top of Westbay™ cap	1629856.58	1768951.62	7065.35
Top of Westbay™ plate	1629856.52	1768961.48	7064.83
Brass cap in R-14 pad	1629855.01	1768953.12	7062.08

The straw wattles and silt fences that are part of the R-14 site best management practice installations remain in place as needed. The site was re-seeded with a Laboratory-specified blend of native grasses mixed with mulch and fertilizer for regrowth of ground cover.

10.0 DEVIATIONS FROM THE R-14 SAP

Appendix A compares the actual characterization activities performed at R-14 with the planned activities described in the Hydrogeologic Workplan (LANL 1998, 59599) and the R-14 SAP (LANL 2002, 73440).

Significant deviations are discussed below:

- *Planned depth.* The SAP stated that the estimated drilling depth would be 1664 ft bgs; actual drill depth was 1327 ft bgs in the Lower Puye Formation and 145 ft in the regional aquifer. Due to limitations on lifting capacity of the drill rig, drilling was stopped at 1327 ft.
- *Surface casing.* The SAP stated that 18-in.-OD steel casing would be set to approximately 50 ft bgs and cemented in place. Because of the very shallow depth of bedrock, the 18-in. surface casing was cemented in place at a depth of 12.2 ft.
- *Conductor casing.* The SAP stated that 11.75-in. steel casing would be permanently installed from 0 to approximately 700 to 800 ft, or approximately 100 ft above the anticipated regional water level. Work performed involved setting 13.375-in. thin-wall steel casing to a depth of 1050 ft and cementing in place. The static water level measured during drilling was at 1181 ft bgs; casing was cemented approximately 131 ft above the regional water level.

11.0 ACKNOWLEDGMENTS

Dynatec Drilling Company provided the rotary drilling services.

Tetra-Tech EM Inc.; D. B. Stephens and Associates, Inc.; and S. M. Stoller provided support for well-site geology and sample collection.

Southwest Mountain Surveys provided the final geodetic survey of finished well components.

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R. Bohn, D. Broxton, E. Louderbough, S. Pearson, W. Stone, and D. Vaniman of Los Alamos National Laboratory prepared and/or reviewed this report. R. Enz and T. Whitacre of DOE also reviewed this report.

12.0 REFERENCES

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Appendix A

Activities Planned for R-14 Compared with Work Performed

Activity	Hydrogeologic Work Plan	Work Plan for Mortandad Canyon	R-14 Sampling and Analysis Plan	R-14 Actual Work
Planned Depth	100 to 500 ft below ground surface (bgs) into the regional aquifer	R-14 proposed depth of 1670 ft bgs	Estimated depth of 1664 ft bgs	Total drill depth 1327 ft bgs
Drilling Method	Methods may include, but are not limited to, hollow stem auger (HSA), air-rotary/Odex/ Stratex, air-rotary/ Barber rig, and mud-rotary drilling	Methods may include, but are not limited to HSA, air-rotary/Odex/Stratex, air-rotary/Barber rig, and mud-rotary drilling	Air rotary core, mud rotary flooded-reverse circulation, and fluid-assist air rotary with casing advance	Air rotary core with wireline retrieval, mud rotary flooded-reverse circulation, and fluid-assist air rotary with casing advance.
Amount of Core	10% of the borehole	Approximately 10%	Continuous core first 300 ft of borehole	Core from 0 to 306 ft bgs
Lithologic Log	Log to be prepared from core, cuttings, and drilling performance data.	Log to be prepared from core, cuttings, and drilling performance	Log to be prepared from core, cuttings, geophysical logs and drilling performance.	Log prepared from core, cuttings, geophysical logs, and drilling performance
Number of Water Samples Collected for Contaminant Analysis	A water sample may be collected from each saturated zone, five zones assumed. The number of sampling events after well completion is not specified.	For planning and conceptual design purposes, it has been assumed that four water-bearing zones will be encountered. Groundwater samples will be collected from each water-bearing zone.	No borehole groundwater screening samples will be collected during drilling.	No water samples obtained during drilling.
Water Sample Analysis	Initial sampling: Radiochemistry I, II, and III, tritium, general inorganics, stable isotopes, volatile organic compounds (VOCs), and metals. Saturated zones: radionuclides (tritium, ^{90}Sr, ^{137}Cs, ^{241}Am, plutonium isotopes, uranium isotopes, gamma spectrometry, and gross alpha, beta, and gamma), stable isotopes (hydrogen, oxygen, and in special cases nitrogen), major ions (cations and anions), trace metals, and trace elements	Analytical suite for intermediate perched zone and regional aquifer groundwater Samples: major and minor ions, trace elements, organic compounds, dissolved organic carbon, total suspended solids, total dissolved solids, neutral species (SiO_2), hardness, cyanide, stable and radiogenic isotopes, and radionuclides.	Metals (dissolved), Anions (dissolved), 99Tc, gamma spec, ^{241}Am, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{234}U, ^{235}U, ^{238}U, ^{90}Sr, stable isotopes (^{18}O/^{16}O, D/H, ^{15}N/^{14}N), tritium, tritium (low level or direct counting), RVgross-alpha, beta, gamma, TUICPMS, TKN, CLO^{4-}	During well completion and development, groundwater samples (from screens 1 and 2) were analyzed for Metals (dissolved), Anions (dissolved), ^{241}Am, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{234}U, ^{235}U, ^{238}U, ^{90}Sr, stable isotopes (18O/16O, D/H, 15N/14N), tritium, tritium (low level or direct counting), U-total, perchlorate, alkalinity, and TKN.

Activity	Hydrogeologic Work Plan	Work Plan for Mortandad Canyon	R-14 Sampling and Analysis Plan	R-14 Actual Work
Water Sample Field Measurements	Alkalinity, pH, specific conductance, temperature, turbidity	Alkalinity, pH, specific conductance, temperature, dissolved oxygen, turbidity	pH, specific conductance, temperature, turbidity	Parameters measured: pH, specific conductance, temperature, turbidity
Number of Core/ Cuttings Samples Collected for Contaminant Analysis	Twenty samples of core or cuttings to be analyzed for potential contaminant identification in each borehole.	Seventy-three samples of core or cuttings to be analyzed for potential contaminant identification in each borehole.	During coring, anion, stable isotope, radionuclide, and tritium profiles will be determined from the level of the canyon floor to the upper part of the Otowi Member (approximately 300 ft in depth). Up to five core or cuttings samples will be collected for geochemical and contaminant characterization within water-bearing zones encountered during drilling.	24 core/cuttings samples collected and submitted for analysis.
Core/Cuttings Sample Analytes	Uppermost core or cuttings sample to be analyzed for a full range of compounds: deeper samples will be analyzed for the presence of radiochemistry I, II, and III analytes, tritium (low and high detection levels), and metals. Four samples to be analyzed for VOCs.	Analytical suite for core and cuttings samples includes anions, trace elements, organic compounds, total organic carbon, cyanide, and radionuclides.	Analytical suite for core and cuttings samples includes anions, stable isotopes, tritium profiles, perchlorate, TKN, stable isotopes, ^{241}Am, ^{238}Pu, ^{239,240}Pu, ^{234}U, ^{235}U, ^{238}U, ^{90}Sr, gamma spectroscopy, gross alpha, beta, and gamma, radionuclides, and metals.	Core samples were analyzed for anions, stable isotopes (18O/16O, D/H, 15N/14N), ^{241}Am, ^{238,239,240}Pu, ^{234,235,238}U, ^{90}Sr, gamma spectroscopy, tritium and gross alpha, beta, and gamma.
Laboratory Hydraulic-Property Tests	Physical properties analyses will be conducted on 5 core samples and will typically include moisture content, porosity, particle density, bulk density, saturated hydraulic conductivity, and water retention characteristics.	Physical properties analyses will be conducted on core samples and will typically include: moisture content, moisture potential, and saturated hydraulic conductivity.	Physical properties analyses will be conducted on core samples for moisture content.	No laboratory hydraulic property tests performed.

Activity	Hydrogeologic Work Plan	Work Plan for Mortandad Canyon	R-14 Sampling and Analysis Plan	R-14 Actual Work
Geology	Ten samples of core or cuttings will be collected for petrographic, X-ray fluorescence (XRF) and X-ray diffraction (XRD) analyses.	Selected samples of core or cuttings will be collected for petrographic, (XRF), (XRD) and K/Ar or 39Ar/40Ar isotopic dating analyses.	Analytical testing of samples may include mineralogy by XRD, petrography by modal analysis of thin sections, by electron microprobe, and/or by scanning electron microscope, and geochemistry by XRF	Eleven samples were characterized for mineralogy, petrography, and rock chemistry.
Geophysics	In general, open-hole geophysics includes caliper, electromagnetic Induction, natural gamma, magnetic susceptibility, borehole color videotape (axial and sidescan), fluid temperature (saturated), fluid resistivity (saturated), single-point resistivity (saturated), and spontaneous potential (saturated). In general, cased-hole geophysics includes: Gamma-gamma density, natural gamma, and thermal neutron.	Geophysical logs will be run in the boreholes, and compact neutron moisture logs may be run in shallower portions of the boreholes. Natural gamma, neutron moisture, and density logs may be run in shallower portions of the boreholes. Natural gamma, neutron moisture, and density logs may be run if the drilling method and borehole stability permit. Other geophysical logs may be considered if, in the opinion of the technical team, they will satisfy a technical need. In general, open-hole geophysics includes caliper, electromagnetic induction, magnetic susceptibility, borehole color videotape (axial and sidescan), fluid temperature (saturated), single-point resistivity (saturated), and spontaneous potential (saturated). In general, cased-hole geophysics includes: gamma-gamma density, natural gamma, and thermal neutron.	In general, open-hole geophysics includes caliper, electromagnetic Induction, natural gamma, magnetic susceptibility, borehole color videotape (axial and sidescan), fluid temperature (saturated), fluid resistivity (saturated), single-point resistivity (saturated), and spontaneous potential (saturated). In general, cased-hole geophysics includes: Gamma-Gamma Density, Natural Gamma, and Thermal Neutron.	LANL tools: 0–12.2 ft bgs (cased), 12.2–1068 ft bgs (open hole): video, natural gamma, induction; 0–1327 ft bgs (cased): natural gamma; 0–1315 ft bgs (well): video Schlumberger geophysics: 0–12.2 ft bgs (cased), 12.2–1068 ft bgs (open hole): lithodensity, spectral gamma, natural gamma elemental capture, thermal-epithermal neutron, combinable magnetic resonance, and natural gamma

Activity	Hydrogeologic Work Plan	Work Plan for Mortandad Canyon	R-14 Sampling and Analysis Plan	R-14 Actual Work
Water-Level Measurements	Procedures and methods not specified in Hydrogeologic Workplan.	Procedures and methods not specified in Hydrogeologic Workplan.	Water levels will be determined for each saturated zone by water-level meter or by pressure transducer.	A water-level meter was used to determine groundwater levels.
Field Hydraulic-Property Tests	Tests to be conducted not specified in Hydrogeologic Workplan.	Tests to be conducted not specified in Hydrogeologic Workplan.	Slug tests will be performed following well development.	Falling head injection tests were conducted on screen #2.
Surface Casing	Approximately 20-in. outer diameter (OD), extends from land surface to 10-ft depth in underlying competent layer and grouted in place.	Approximately 20-in. OD, extends from land surface to 10-ft depth in underlying competent layer and grouted in place.	Install 18-in. or 20-in. OD steel casing to approximately 50 ft bgs and cement in place.	18-in. OD steel casing set at 12.2 ft bgs
Conductor Casing	Unless other technical methods are applied, a temporary steel casing, up to 14-in. OD, will be advanced to total depth of borehole.	Unless other technical methods are applied, a temporary steel casing, up to 14-in. OD, will be advanced to total depth of borehole.	Install 113/4-in. OD steel casing from 0 to ~700 to 800 ft bgs or approximately 100 ft above anticipated regional water level.	Install 13.375-in.-OD thin-wall steel casing from 0 to 1050 ft bgs.
Minimum Well Casing Size	6.625-in. OD	6.625-in. OD	5-in.-OD x 4.5-in.-ID	5-in.-OD x 4.5-in.-ID stainless steel casing w/ external couplings.
Well Screen	Machine-slotted (0.01-in.), stainless steel screens with flush-jointed threads; number and length of screens to be determined on a site-specific basis and proposed to NMED.	Machine-slotted (0.01-in.), stainless steel screens with flush-jointed threads; number and length of screens to be determined on a site-specific basis and proposed to NMED.	Well screen shall be constructed with multiple sections of 5-in. OD stainless steel pipe with wire wrap (0.01-in. slot opening).	Screened intervals constructed of 5.56-in.-OD (4.5-in.-ID) pipe with stainless steel, wire-wrapped, 0.010-in. slotted screen

Activity	Hydrogeologic Work Plan	Work Plan for Mortandad Canyon	R-14 Sampling and Analysis Plan	R-14 Actual Work
Filter Material	>90% silica sand, properly sized for the 0.010-in. slot size of the well screen; extends 2 ft above and below the well screen.	>90% silica sand, properly sized for the 0.010-in. slot size of the well screen; extends 2 ft above and below the well screen.	Filter pack shall extend at least 5 ft and no more than 10 ft above and below each well screen. No differentiation made between primary and secondary filter packs.	Primary filter pack consisted of 20/40 silica sand placed 6.1 ft below and 5.5 ft above screen #2. Secondary filter pack consisted of 30/70 silica sand placed in a layer 5.3 ft thick above screen. Primary filter pack consisted of 20/40 silica sand placed 7 ft below and 3.8 ft above screen 1. Secondary filter pack consisted of slough in a layer 1-ft-thick below and 30/70 silica placed in a layer 6.1-ft thick above primary filter pack.
Backfill Material (exclusive of filter materials)	Uncontaminated drill cuttings below sump and bentonite above sump.	Uncontaminated drill cuttings below sump and bentonite above sump.	Bentonite and cement in borehole or well annulus.	Slough in borehole and annulus below and around well sump from TD to 8.5 ft below bottom of well screen. Slough and bentonite seal above and below screen #1 filter pack. Slough and bentonite seal above and below screen #2 filter pack One cement plug from 1057.8 to 1069.6 ft and cement-bentonite grout from surface to 77 ft bgs.
Sump	Stainless steel casing with an end cap	Stainless steel casing with an end cap	Not specified	5-in.-OD stainless steel casing, 22.5 ft long, with an end cap.
Bottom Seal	Bentonite	Bentonite	Bentonite	Bentonite

Appendix B

Drill-Additive Product Specifications
(CD attached to inside back cover)

Appendix C

Lithology Log

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Construction Fill/reworked material	Construction fill. Upper 6 in. consists of base-course gravel; remaining interval made up of loose reworked materials derived from the Bandelier Tuff that contain organic debris.	0–3.5	7062.1–7058.6
Qbt 2, Tshirege Member of the Bandelier Tuff	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, moderately welded. Composed of 4%–5% crystalline devitrified pumice fragments (up to 1.5 cm); 35% quartz and sanidine phenocrysts; 60% ash matrix, local yellowish Fe-oxide staining, core moist.	3.5–9.2	7058.6–7052.9
	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, moderately to strongly welded. Composed of 10% flattened devitrified pumice lapilli (up to 2.0 cm); 25% quartz and sanidine phenocrysts (up to 2.0 mm); 60%–70% ash matrix, local yellowish brown oxide staining, moist.	9.2–14.2	7052.9–7047.9
	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, pumice-poor, moderately welded. Composed of 1% white crystalline pumice; 25% quartz and sanidine phenocrysts (up to 2.0 mm); 70%–80% ash matrix, local yellowish brown oxide staining and oxidation of ferromagnesian minerals.	14.2–19.2	7047.9–7042.9
	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, moderately to strongly welded. Composed of 15% pale gray crystalline pumice (up to 2 .0 cm) that are flattened; 30% quartz and sanidine phenocrysts (up to 3.0 mm); 50%–60% ash matrix with yellowish-brown oxide staining, particularly around pumices, and oxidation of ferromagnesian minerals.	19.2–24.2	7042.9–7037.9
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly to moderately welded. Composed of 10% pale gray crystalline hornblende-bearing pumice (up to 1.5 cm) that are flattened; 20% quartz and sanidine phenocrysts (up to 3.0 mm); 70% ash matrix. Core moist.	24.2–28.7	7037.9–7033.4
	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, moderately to strongly welded. Composed of 12% gray crystalline devitrified and partly flattened pumice (up to 1.0 cm); 25% quartz and sanidine phenocrysts (up to 2.0 mm); 60%–70% ash matrix displays yellowish brown oxidation stains. Core moist.	28.7–34.3	7033.4–7027.8
	Rhyolite tuff, pale yellowish-brown (10YR 6/2), moderately welded. Composed of 5% light gray crystalline devitrified and flattened pumice (up to 1.5 cm); 20% quartz and sanidine phenocrysts (up to 2.0 mm); 70%–80% ash matrix with abundant brown oxidation stains. Core moist.	34.3–40.8	7027.8–7021.3
	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal-rich, moderately welded, locally fissile. Composed of 5% gray crystalline slightly flattened pumice (up to 1.0 cm); 25% quartz and sanidine phenocrysts (up to 4.0 mm); 70% ash matrix displays brown oxidation stains. Core moist.	40.8–43.8	7021.3–7018.3
	Rhyolite tuff, light brownish-gray (5YR 6/1), moderately to strongly welded. Composed of 5% gray devitrified and flattened pumice lapilli (up to 2.0 cm); 18% quartz and sanidine phenocrysts (up to 6.0 mm); 70%–75% devitrified ash matrix with abundant yellowish-brown oxidation stains. Core moist.	43.8–48.8	7018.3–7013.3

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbt 2, Tshirege Member of the Bandelier Tuff	No core recovery in this interval.	48.8–54.3	7013.3–7007.8
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly welded. Composed of 18% gray to yellowish brown crystalline (devitrified) pumice lapilli (up to 5.0 cm) that are mostly flattened; 18% quartz and sanidine phenocrysts (up to 4.0 mm); 50%–60% microcrystalline devitrified ash matrix. Core dry.	54.3–56.0	7007.8–7006.1
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly welded to nonwelded partings that are 0.5 to 1.0 cm thick. Composed of 5% gray crystalline (devitrified) pumice lapilli (1.0 to 5.0 cm); 12% quartz and sanidine phenocrysts (up to 2.0 mm); 80%–85% devitrified ash matrix with many yellow-brown oxidation stains. Core dry.	56–61	7006.1–7001.1
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly welded, fissile. Composed of 12% brownish-gray devitrified pumice lapilli (up to 1.5 cm); 8% quartz and sanidine phenocrysts (up to 2.0 mm), some dacitic xenolithic fragments (up to 4.0 cm); 70%–80% ash matrix with numerous brown oxidation stains.	61–66	7001.1–6996.1
	Rhyolite tuff, light brownish gray (5YR 6/1), weakly welded, fissile. Composed of 20% gray to brownish gray devitrified (crystalline) pumice lapilli (up to 2.0 cm) that are flattened; 10% quartz and sanidine phenocrysts (up to 2.0 mm); 70% ash matrix with numerous brown oxidation stains.	66–71	6996.1–6991.1
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly welded to nonwelded. Composed of 8% gray to brownish-gray devitrified (crystalline) pumice lapilli (up to 0.5 cm) that are partly flattened; 18% quartz and sanidine phenocrysts (up to 2.0 mm); 70%–75% ash matrix with yellowish-brown oxidation stains. Core dry.	71–75.6	6991.1–6986.5
	Rhyolite tuff, light brownish-gray (5YR 6/1), weakly welded to nonwelded, fissile with partings up to 1.0 cm. Composed of 12% grayish-white devitrified (crystalline) pumice lapilli (up to 1.0 cm) that are partly flattened; 10% quartz and sanidine phenocrysts (up to 1.0 mm); 75%–80% ash matrix with brown oxidation stains. Core dry. Qbt 2/Qbt 1v contact estimated at 80.0 ft bgs.	75.6–81	6986.5–6981.1
Qbt 1, (undivided), Tshirege Member of the Bandelier Tuff	Rhyolite tuff, light brownish-gray (5YR 6/1), pumice-rich, weakly welded, local partings. Composed of 25% gray to brownish-gray crystalline pumice lapilli (up to 3.0 cm) that are flattened; 8% quartz and sanidine phenocrysts (up to 2.0 mm); 60%–65% ash matrix with brown oxidation stains. Core dry.	81–86	6981.1–6976.1
	Rhyolite tuff, light brownish-gray (5YR 6/1), pumice-rich, weakly welded to nonwelded, locally fissile. Composed of 35% gray microcrystalline (devitrified) pumice lapilli (up to 1.0 cm) that are partly flattened; 5% quartz and sanidine phenocrysts (up to 1.0 mm); 60% ash matrix with brown oxidation stains. Core dry.	86–91	6976.1–6971.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbt 1, (undivided), Tshirege Member of the Bandelier Tuff	Rhyolite tuff, pinkish-gray (5YR 8/1), pumice-rich, weakly welded to nonwelded. Composed of 30% gray microcrystalline (devitrified) pumice lapilli (up to 1.5 cm) that are partly flattened; 3% quartz and sanidine phenocrysts (up to 2.0 mm); 65%–70% ash matrix with brown oxidation stains. Core dry.	91–96	6971.1–6966.1
	Rhyolite tuff, pinkish gray (5YR 8/1), pumice-rich, weakly welded to nonwelded. Composed of 35% gray to grayish brown microcrystalline (devitrified) pumice lapilli (up to 2.0 cm) that are partly flattened; 8% quartz and sanidine phenocrysts (up to 1.0 mm); 55%–60% ash matrix with local brown oxidation stains. Core moist.	96–101	6966.1–6961.1
	Rhyolite tuff, pinkish gray (5YR 8/1), pumice-rich, nonwelded. Composed of 30% gray to brown microcrystalline (devitrified) pumice lapilli (up to 1.5 cm) that are flattened; 10% quartz and sanidine phenocrysts (up to 3.0 mm); 60% ash matrix with minor brown oxidation staining. Core dry.	101–106	6961.1–6956.1
	Rhyolite tuff, pinkish-gray (5YR 8/1), pumice-rich, nonwelded. Composed of 30% brown fibrous crystalline (devitrified) pumice lapilli (up to 1.8 cm); 12% quartz and sanidine phenocrysts (up to 2.0 mm); 60%–65% ash matrix with minor brown oxidation staining. Core moist.	106–111	6956.1–6951.1
	Rhyolite tuff, pinkish-gray (5YR 8/1), pumice- and crystal-rich, nonwelded. Composed of 30% brown fibrous crystalline (devitrified) pumice lapilli (up to 2.5 cm); 30% sanidine and pinkish quartz phenocrysts (up to 2.0 mm); 35%–40% ash matrix with minor brown oxidation staining; minor dacitic xenoliths (up to 8.0 mm). Core moist.	111–116	6951.1–6946.1
	Rhyolite tuff, pinkish-gray (5YR 8/1), pumice- and crystal-rich, nonwelded. Composed of 25% brown fibrous crystalline pumice lapilli (up to 1.5 cm); 20% sanidine and pinkish quartz phenocrysts (up to 3.0 mm); 5% oxidized basalt and/or latite xenoliths (up to 2.5 cm); 50% ash matrix. Core moist.	116–119	6946.1–6943.1
	Rhyolite tuff, pale orange (10YR 8/2), nonwelded. Composed of 5% light brownish-gray fibrous microcrystalline pumice lapilli (up to 1.5 cm); 18%–20% sanidine and quartz phenocrysts (up to 2.0 mm); 2%–5% dacitic xenoliths (up to 3.0 cm); 70%–75% altered ash matrix is waxy and clay-rich. Core moist.	119–123.4	6943.1–6938.7
	No core recovery in this interval.	123.4–126	6938.7–6936.1
	Rhyolite tuff, grayish-orange (10YR 7/4), pumice-rich, vitric, nonwelded. Composed of 60% orange fibrous glassy pumice lapilli (up to 1.5 cm); 10% sanidine and quartz phenocrysts (up to 2.0 mm); rare dacitic xenoliths; 30% biotite-bearing vitric ash matrix. Core moist.	126–131	6936.1–6931.1
	Rhyolite tuff, light brown (5YR 6/4), pumice-rich, vitric, nonwelded. Composed of 45% fibrous glassy pumice lapilli (up to 2.5 cm); 20% sanidine and quartz phenocrysts (up to 2.0 mm); 2% dacitic xenoliths (up to 3.0 mm); 35%–40% vitric ash matrix with abundant glass shards. Core dry.	131–136	6931.1–6926.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbt 1, (undivided), Tshirege Member of the Bandelier Tuff	Rhyolite tuff, pale yellowish-brown (10YR 6/2), pumice-rich, vitric, nonwelded. Composed of 30% fibrous glassy pumice lapilli (up to 1.8 cm); 15% sanidine and quartz phenocrysts (up to 3.0 mm); 10% gray to reddish-brown dacitic xenoliths; 45%–50% vitric ash matrix with abundant glass shards. Core dry.	136–140.4	6926.1–6921.7
	Rhyolite tuff, grayish-orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 30% fibrous glassy pumice lapilli (up to 2.0 cm); 15% sanidine and quartz phenocrysts (up to 3.0 mm); 3% gray to reddish-brown volcanic xenoliths; 50%–55% vitric ash matrix. Core dry.	140.4–143.5	6921.7–6918.6
	Rhyolite tuff, grayish-orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 30% fibrous glassy pumice lapilli (up to 0.8 cm); 15% sanidine and quartz phenocrysts (up to 3.0 mm); rare gray volcanic xenoliths (up to 3.0 mm); 50%–55% vitric ash matrix. Core dry.	143.5–148.5	6918.6–6913.6
	Rhyolite tuff, grayish-orange pink (5YR 7/2), vitric, nonwelded. Composed of 10% fibrous glassy pumice lapilli (up to 3.5 cm); 18% sanidine and quartz phenocrysts (up to 2.0 mm); 2% gray to reddish-brown dacitic xenoliths (up to 1.0 mm); 65%–70% vitric ash matrix with abundant glass shards. Core dry.	148.5–153.4	6913.6–6908.7
	Rhyolite tuff, grayish-orange pink (5YR 7/2), vitric, nonwelded. Composed of 5% fibrous glassy pumice lapilli (up to 1.0 cm); 15% sanidine and quartz phenocrysts (up to 2.0 mm); 2% gray to reddish-brown quartz-latite xenoliths (up to 1.0 mm); 75%–80% vitric ash matrix with abundant glass shards. Core dry.	153.4–158.8	6908.7–6903.3
	Rhyolite tuff, grayish orange pink (5YR 7/2), vitric, nonwelded. Composed of 15% fibrous glassy pumice lapilli (up to 3.5 cm); 15% sanidine and quartz phenocrysts (up to 2.0 mm); 1%–2% gray to reddish-brown dacitic xenoliths (up to 1.0 mm); 65%–70% vitric ash matrix with abundant glass shards. Core dry.	158.8–162.5	6903.3–6899.6
	Rhyolite tuff, grayish-orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 25% fibrous glassy pumice lapilli (up to 3.5 cm); 15% sanidine and quartz phenocrysts (up to 2.0 mm); 1% gray to reddish-brown dacitic xenoliths (up to 1.0 mm); 65%–70% vitric ash matrix with abundant glass shards. Core dry.	162.5–164.2	6899.6–6897.9
	Rhyolite tuff, grayish orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 30% fibrous glassy pumice lapilli (up to 2.0 cm); 15% sanidine and quartz phenocrysts (up to 2.0 mm); rare volcanic xenoliths (up to 1.0 mm); 55% vitric ash matrix with abundant glass shards. Core dry.	164.2–168.3	6897.9–6893.8
	No core recovery in this interval.	168.3–176	6893.8–6886.1
	Rhyolite tuff, grayish-orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 25% fibrous glassy pumice lapilli (up to 2.0 cm); 10% sanidine and quartz phenocrysts (up to 2.0 mm); rare volcanic xenoliths (up to 1.0 mm); 60%–65% vitric ash matrix with abundant glass shards. Core dry.	176–178	6886.1–6884.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbt 1, (undivided), Tshirege Member of the Bandelier Tuff	No core recovery in this interval.	178–181	6884.1–6881.1
	Rhyolite tuff, pinkish-gray (5YR 8/1), vitric, nonwelded. Composed of 20% glassy pumice lapilli (up to 3.5 cm); 12% sanidine and quartz phenocrysts (up to 4.0 mm); 1% dark gray dacitic xenoliths (up to 4.0 mm); 65%–70% vitric ash matrix with abundant glass shards. Core dry.	181–182.8	6881.1–6879.3
	Rhyolite tuff, grayish-orange pink (5YR 7/2), pumice-rich, vitric, nonwelded. Composed of 25% fibrous glassy pumice lapilli (up to 3.0 cm); 15% sanidine and quartz phenocrysts (up to 4.0 mm); 1% gray dacitic xenoliths (up to 5.0 mm); 60%–65% vitric ash matrix with abundant glass shards. Core moist.	182.8–188.3	6879.3–6873.8
	No core recovery in this interval.	188.3–191	6873.8–6871.1
	Rhyolite tuff, very pale orange (10YR 8/2), pumice-rich, vitric, nonwelded. Composed of 25%–35% fibrous glassy pumice lapilli (up to 3.0 cm); 10%–15% sanidine and quartz phenocrysts (up to 2.0 mm); 1% volcanic xenoliths (up to 4.0 mm); 50%–60% vitric ash matrix.	191–194.1	6871.1–6868
Qbt 1	No core recovery in this interval.	194.1–201	6868–6861.1
	Rhyolite tuff, very pale orange (10YR 8/2), pumice-rich, vitric, nonwelded. Composed of 35% fibrous glassy pumice lapilli (up to 1.5 cm); 15% sanidine and quartz phenocrysts (up to 2.0 mm); 1% volcanic xenoliths (up to 1.0 mm); 45%–50% vitric ash matrix. Core dry.	201–203	6861.1–6859.1
	No core recovery in this interval.	203–206	6859.1–6856.1
	Rhyolite tuff, very pale orange (10YR 8/2), vitric, nonwelded. Composed of 5% fibrous glassy pumice lapilli (up to 1.5 cm); 15% sanidine and quartz phenocrysts (up to 3.0 mm); 1% gray to reddish-brown volcanic xenoliths (up to 4.0 mm); 75%–80% vitric ash matrix. Core dry.	206–207.8	6856.1–6854.3
	No core recovery in this interval.	207.8–211	6854.3–6851.1
	Rhyolite tuff, pinkish-gray (5YR 8/1), vitric, nonwelded, friable. Composed of 18% white glassy pumice lapilli (up to 2.5 cm); 18% sanidine and quartz phenocrysts (up to 4.0 mm); 1%–2% gray to reddish-brown volcanic xenoliths (up to 5.0 mm); 55%–60% vitric ash matrix with abundant glassy shards. Core dry.	211–213.8	6851.1–6848.3
	No core recovery in this interval.	213.8–216	6848.3–6846.1
	Volcaniclastic sediments, pale yellowish-brown (10YR 6/2), tuffaceous, unconsolidated, pumice-rich. Composed of 60% white glassy pumice fragments (up to 1.0 cm); 30% sanidine and quartz grains; 3% lithic fragments; 7%–10% ash and silt. Core moist.	216–218.3	6846.1–6843.8
Qct Cerro Toledo Interval	No core recovery in this interval. Qbt 1g/Qct contact estimated at 220.0 ft bgs.	218.3–221	6843.8–6841.1
	Volcaniclastic sediments, silty sand (SM), with light brown gravel (5YR 6/4), tuffaceous, unconsolidated, pebble-size clasts up to 1.5 cm. Composed of volcanic lithologies with minor pumice fragments. Core dry.	221–223.2	6841.1–6838.9

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qct Cerro Toledo Interval	No core recovery in this interval.	223.2–226	6838.9–6836.1
	Volcaniclastic sediments, sand (SW) with gravel, grayish-orange (10YR 7/4), 10% subrounded gravel clasts up to 3.0 cm, unconsolidated. Composed of volcanic lithologies (dominantly dacite). Core moist.	226–229	6836.1–6833.1
	No core recovery in this interval.	229–232	6833.1–6830.1
	Very poor core recovery in this interval. Volcaniclastic gravels, dacite-rich.	232–232.4	6830.1–6829.7
	No core recovery in this interval. Qct/Qbo contact estimated at 244.0 ft bgs.	232.4–244	6829.7–6818.1
Qbo Otowi Member of the Bandelier Tuff	Rhyolite tuff, very pale orange (10YR 8/2), vitric, nonwelded. Composed of 20% orange to yellowish-brown glassy fibrous pumice lapilli (up to 3.0 cm); 5% quartz and sanidine phenocrysts (up to 2.0 mm); 2% reddish-brown volcanic xenoliths (up to 5 mm); 70%–75% vitric ash matrix with abundant glassy shards and streaks of orange Fe-oxide staining. Core dry.	244–248.8	6818.1–6813.3
	No core recovery in this interval.	248.8–251	6813.3–6811.1
	Rhyolite tuff, moderate orange pink (5YR 8/4), vitric, nonwelded. Composed of 10%–20% glassy fibrous pumice lapilli; 10%–20% quartz and sanidine phenocrysts; 3%–5% gray to reddish-brown volcanic xenoliths (up to 5.0 mm); 55–65% vitric ash matrix with glassy shards. Core dry.	251–252.1	6811.1–6810
	No core recovery in this interval.	252.1–263.8	6810–6798.3
	Rhyolite tuff, very pale orange (10YR 8/2), vitric, nonwelded. Composed of 15%–20% glassy fibrous pumice lapilli; 20% quartz and sanidine phenocrysts; 1%–2% volcanic xenoliths; 60%–65% vitric ash matrix. Core dry.	263.8–272.9	6798.3–6789.2
	Rhyolite tuff, grayish-orange pink (5YR 7/2), vitric, nonwelded. Composed of 10%–15% glassy fibrous pumice lapilli; 20%–25% quartz, sanidine, and ferromagnesian phenocrysts; 1%–2% volcanic xenoliths; 50%–60% vitric ash matrix. Core dry.	272.9–278.3	6789.2–6783.8
	Rhyolite tuff, very pale orange (10YR 8/2), vitric, nonwelded. Composed of 10%–15% glassy fibrous pumice lapilli; 20% quartz and sanidine phenocrysts (up to 2.0 mm); 3% ferromagnesian phenocrysts; 1%–2% volcanic xenoliths; 55%–65% vitric ash matrix. Core slightly moist.	278.3–287.2	6783.8–6774.9
	Rhyolite tuff, very pale orange (10YR 8/2), vitric, nonwelded. Composed of 20% glassy fibrous pumice lapilli; 20% quartz and sanidine phenocrysts (up to 2.0 mm); 2% ferromagnesian phenocrysts; 2% volcanic xenoliths; 50%–60% vitric ash matrix. Core slightly moist.	287.2–299.6	6774.9–6762.5
	No core recovery in this interval. Rotary drill cuttings collected and described in the interval 306 to the total borehole depth at 1325 ft bgs.	299.6–306	6762.5–6756.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbo Otowi Member of the Bandelier Tuff	Rhyolite tuff, light brownish-gray (5YR 6/1), lithic-rich, poorly welded. WR/+10F: (i.e., unsieved sample and plus No. 10 sieved sample fraction) 20% glassy, fibrous and sugar-textured pumice fragments (up to 1 cm); 10% quartz and sanidine crystals (up to 3.0 mm); 70% gray to reddish-brown dacitic and andesitic lithic fragments (up to 0.7 cm).	306–311	6756.1–6751.1
	Rhyolite tuff, medium light gray (N6), lithic-rich, poorly welded to nonwelded. WR/+10F: 15% pale orange glassy, fibrous pumice fragments (up to 0.8 cm); 10% quartz and sanidine crystals; 70%–75% gray to reddish-brown dacitic and andesitic lithic fragments (up to 0.7 cm) with minor siltstone and obsidian.	311–318	6751.1–6744.1
	Rhyolite tuff, very light gray (N8), lithic-rich, poorly welded to nonwelded. WR/+10F: 5% pale orange glassy, fibrous pumice fragments (up to 0.7 cm); 20% quartz and sanidine crystals (up to 2.0 mm); 70%–75% gray to reddish-brown dacitic and andesitic lithic fragments (up to 0.7 cm); 5% volcanic ash.	318–323	6744.1–6739.1
	Rhyolite tuff, medium light gray (N6), lithic-rich, poorly welded to nonwelded. WR/+10F: 20% white to pale orange glassy, fibrous pumice fragments (up to 0.7 cm); 20% quartz and sanidine crystals (up to 4.0 mm); 57% gray to pink dacitic lithic fragments (up to 0.7 cm); 3% volcanic ash.	323–328	6739.1–6734.1
	Rhyolite tuff, very light gray (N8), crystal-rich, poorly welded to nonwelded. WR/+10F: 5%–10% white to pale orange glassy, fibrous pumice fragments (up to 0.8 cm); 60%–70% quartz and sanidine crystals (up to 3.0 mm); 20% dacitic and andesitic lithic fragments; 10% volcanic ash.	328–333	6734.1–6729.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 5% white to pale orange glassy, fibrous pumice fragments (up to 0.5 cm); 50% quartz and sanidine crystals (up to 4.0 mm); 40% dacitic lithic fragments; 5%–10% volcanic ash.	333–353	6729.1–6709.1
	Rhyolite tuff, very light gray (N8), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 2% white to pale orange glassy, fibrous pumice fragments; 60% quartz and sanidine crystals; 35%–40% dacitic and minor obsidian lithic fragments; 1%–3% volcanic ash.	353–358	6709.1–6704.1
	Rhyolite tuff, light gray (N7), lithic-rich, poorly welded to nonwelded. WR/+10F: 3%–8% white to pale orange glassy, fibrous pumice fragments; 15% quartz and sanidine crystals; 75% dacitic and andesite lithic fragments, minor obsidian; 2%–3% volcanic ash.	358–378	6704.1–6684.1
	Rhyolite tuff, very light gray (N8), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 2%–3% white to light gray glassy, fibrous pumice fragments; 50% quartz and sanidine crystals; 45% dacitic and andesite lithic fragments, minor obsidian; 2%–3% volcanic ash.	378–383	6684.1–6679.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbo Otowi Member of the Bandelier Tuff	Rhyolite tuff, light brownish-gray (5YR 6/1), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 3% white to pale orange glassy, fibrous to sugar-textured pumice fragments; 45% quartz and sanidine crystals; 47% dacitic, rhyolite, and obsidian lithic fragments; 5% volcanic ash.	383–393	6679.1–6669.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 1%–2% white to pale orange glassy, fibrous pumice fragments; 25% quartz and sanidine crystals; 65% dacitic, rhyodacite, and rhyolite lithic fragments; 10% volcanic ash.	393–398	6669.1–6664.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 5% white to pale orange glassy, fibrous to sugar-textured pumice fragments; 40% quartz and sanidine crystals (up to 3 mm); 45% dacitic, rhyodacite, and rhyolite lithic fragments, minor obsidian; 10% volcanic ash.	398–408	6664.1–6654.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 3%–5% white to pale orange glassy, fibrous to sugar-textured pumice fragments; 40% quartz and sanidine crystals (up to 3 mm); 40% dacitic with minor andesitic, rhyodacite, and obsidian lithic fragments; 15%–20% volcanic ash.	408–413	6654.1–6649.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 2% white to pale orange glassy, fibrous pumice fragments; 50% quartz and sanidine crystals (up to 3 mm); 35%–40% dacitic with minor andesitic, rhyodacite, and obsidian lithic fragments; 10% volcanic ash.	413–418	6649.1–6644.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 2%–3% white to pale orange glassy, fibrous to sugar-textured pumice fragments (up to 0.6 cm); 35% quartz and sanidine crystals (up to 3.0 mm); 50%–55% dacitic lithic fragments with minor andesite, rhyodacite, and obsidian (up to 4.0 mm); 7% volcanic ash.	418–438	6644.1–6624.1
	Rhyolite tuff, light gray (N7), lithic-rich, poorly welded to nonwelded. WR/+10F: 1%–2% white to pale orange glassy, fibrous to sugar-textured pumice fragments (up to 0.3 cm); 25% quartz and sanidine crystals (up to 3.0 mm); 65%–70% dacitic lithic fragments with minor andesite and rhyodacite; 1%–3% volcanic ash.	438–443	6624.1–6619.1
	Rhyolite tuff, medium light gray (N6), pumice- and lithic-rich, poorly welded to nonwelded. WR/+10F: 60% white glassy, fibrous pumice fragments (up to 0.7 cm); 5% quartz and sanidine crystals (up to 3.0 mm); 35% dacite and minor rhyolite lithic fragments; 1%–3% volcanic ash.	443–448	6619.1–6614.1
	Rhyolite tuff, very light gray (N8), crystal-rich, poorly welded to nonwelded. WR/+10F: 1% white glassy, fibrous pumice fragments; 75% quartz and sanidine crystals (up to 4 mm); 15% dacite and andesite lithic fragments; 10% volcanic ash. Some larger crystals and lithic fragments in +10F sample are rounded.	448–453	6614.1–6609.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Qbo Otowi Member of the Bandelier Tuff	Rhyolite tuff, very light gray (N8), crystal-rich, poorly welded to nonwelded. WR/+10F: 5% white glassy, fibrous pumice fragments; 75% quartz and sanidine crystals (up to 4.0 mm); 35% lithic fragments (dacite, andesite, and minor obsidian up to 3.0 mm); 15% volcanic ash.	453–463	6609.1–6599.1
	Rhyolite tuff, very light gray (N8), crystal- and lithic-rich, poorly welded to nonwelded. WR/+10F: 8% white glassy, fibrous pumice fragments (up to 0.5 cm); 45% quartz and sanidine crystals (up to 2.0 mm); 30% lithic fragments (dacite, andesite, and minor obsidian up to 5.0 mm); 17% volcanic ash.	463–478	6599.1–6584.1
	Rhyolite tuff, light gray (N7), crystal-rich, poorly welded to nonwelded. WR/+10F: 8% white glassy, fibrous pumice fragments (up to 0.4 cm); 45% quartz and sanidine crystals (up to 3.0 mm); 25% lithic fragments (dacite and latite up to 5.0 mm); 15% volcanic ash.	478–488	6584.1–6574.1
	Rhyolite tuff, light gray (N7), pumice- and lithic-rich, poorly welded to nonwelded. +10F: 50% white glassy pumice fragments (up to 0.3 cm); 3%–5% quartz and sanidine crystals; 45%–50% dacitic lithic fragments. +35F (i.e., plus No. 35 sieved sample fraction): contains more than 50% quartz and sanidine crystals.	488–498	6574.1–6564.1
	Rhyolite tuff, light gray (N7), crystal- and lithic-rich, poorly welded to nonwelded. WR: 5% white pumice fragments; 60% quartz and sanidine crystals; 35% dacitic lithic fragments.	498–503	6564.1–6559.1
	Rhyolite tuff, light gray (N7), pumice- and lithic-rich, poorly welded to nonwelded. WR/+10F: 40%–50% white glassy, fibrous pumice fragments; 5%–10% quartz and sanidine crystals; 40%–50% volcanic lithic fragments (up to 3 mm).	503–508	6559.1–6554.1
	Rhyolite tuff, light gray (N7), crystal-rich, poorly welded to nonwelded. WR/+10F: 5% white glassy, fibrous pumice fragments (up to 0.3 cm); 70% quartz and sanidine crystals (up to 2 mm); 20% volcanic lithic fragments (dacite and andesite); 5% fine volcanic ash.	508–513	6554.1–6549.1
	Rhyolite tuff, light gray (N7), crystal-rich, poorly welded to nonwelded. WR/+10F: 5% white glassy fibrous pumice fragments (up to 0.4 cm); 20% quartz and sanidine crystals (up to 2 mm); 20% volcanic lithic fragments (dacite and andesite); 5% fine volcanic ash. Qbo/Qbog contact estimated at 522 ft bgs.	513–523	6549.1–6539.1
Qbog, Guaje Pumice Bed	Tephra, medium light gray (N6), crystal- and lithic-rich, nonwelded. WR/+10F: 20% white fibrous to glassy pumice fragments (up to 0.5 cm); 30% quartz and sanidine crystals (up to 3 mm); 50% gray to reddish brown, volcanic lithic fragments (dacite, latite).	523–533	6539.1–6529.1
	Transitional Qbog/Tpf interval-medium light gray (N6), 40% tephra, nonwelded; 60% Tschicoma dacite. WR/+10F: 15% white fibrous to glassy pumice fragments (up to 0.3 cm); 15% quartz and sanidine crystals (up to 3 mm); 10% volcanic ash; 50% dark gray. fine grained dacite lithic fragments. Note: basal Qbog contact with underlying Puye volcanic sediments estimated at 534 ft bgs.	533–538	6529.1–6524.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tpf, Puye Formation, (upper section)	Volcanic sediments, dark gray (N3). +10F: fragments of dacite volcanic rock, aphanitic, aphyric, massive; some remnant tephra present, probably from drilling contamination.	538–543	6524.1–6519.1
	Volcanic sediments, medium dark gray (N4) to dark gray (N3), sparsely porphyritic with aphanitic groundmass, massive. +10F: rare phenocrysts of pyroxene and quartz; minor tephra present, probably from drilling contamination.	543–548	6519.1–6514.1
	Volcanic sediments, medium dark gray (N5), sparsely porphyritic with aphanitic groundmass, massive. +10F: dark gray to reddish-brown dacite fragments, rare phenocrysts of pyroxene and plagioclase; rare tephra present.	548–558	6514.1–6504.1
	Volcanic sediments, medium dark gray (N5), sparsely porphyritic with aphanitic groundmass, massive. +10F: similar lithology to interval 548–558 ft; however, only a small volume of +10F sample recovered.	558–563	6504.1–6499.1
	Volcanic sediments, medium dark gray (N5), sparsely porphyritic with aphanitic groundmass, massive. +10F: dark gray to reddish brown dacite fragments, angular chips, rare phenocrysts of yellowish-green pyroxene and plagioclase; rare tephra present.	563–593	6499.1–6469.1
	Volcanic sediments, pale red (10YR 6/2) to grayish-red (10R 4/2), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: angular chips, rare phenocrysts of yellowish-green pyroxene, plagioclase, and probably quartz; reddish coloration suggests oxidized zone, possible brecciation. Note: basal Tpf contact with underlying section of dacite volcanics estimated at 620 ft bgs.	593–628	6469.1–6434.1
Td, Dacite (unassigned)	Dacite, medium light gray (N6), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: angular chips, light gray to reddish-brown dacite, euhedral phenocrysts of pyroxene, plagioclase, and probably quartz; partly reddish coloration suggests oxidized breccia zone.	628–638	6434.1–6424.1
	Dacite, medium light gray (N6), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: 98% chips light gray to reddish-brown dacite, euhedral phenocrysts of pyroxene, plagioclase, and probably quartz; 1%–2% yellowish-brown sandstone fragments.	638–643	6424.1–6419.1
	Dacite, medium light gray (N6), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips light gray to reddish-brown dacite, minor phenocrysts of translucent yellowish-brown pyroxene, plagioclase, hornblende, and probably quartz.	643–663	6419.1–6399.1
	Dacite, medium light gray (N6), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips light gray to reddish-brown dacite, minor phenocrysts of translucent yellowish-brown euhedral pyroxene, subhedral plagioclase, and euhedral biotite.	663–718	6399.1–6344.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Td, Dacite (unassigned)	Dacite, light gray (N5), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips light gray to reddish-brown dacite, minor phenocrysts of translucent yellowish-brown euhedral pyroxene, subhedral plagioclase, and numerous small mafic minerals. Note: Td/Tpf contact estimated at 768 ft bgs.	718–778	6344.1–6284.1
Tpf, Puye Formation (lower section)	Dacitic sediments, medium light gray (N6), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips light gray to reddish-brown dacite, minor phenocrysts of translucent yellowish-brown euhedral pyroxene, subhedral plagioclase, and small mafic minerals; unidentified sugar-textured crystals, possibly zeolites, in-filling some vugs.	778–838	6284.1–6224.1
	Dacitic sediments, medium gray (N5), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips (flat, platy) of dark gray to reddish-brown dacite, minor phenocrysts of translucent yellowish-brown euhedral pyroxene, subhedral plagioclase, and anhedral quartz; chips of gray clay.	838–848	6224.1–6214.1
	Dacitic sediments, medium dark gray (N4), sparsely porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: chips (flat, platy flakes) of dark gray to reddish brown dacite, minor phenocrysts of translucent yellowish and black opaque euhedral pyroxene, subhedral plagioclase, and anhedral quartz; abundant chips of gray clay denote an apparent zone of clay alteration from 848 to 878 ft bgs.	848–863	6214.1–6199.1
	Clayey sand with dacites, light brownish-gray (5YR 6/1). +10F: lenticular chips of dacite, sparsely porphyritic with aphanitic groundmass, euhedral pyroxene, subhedral plagioclase; abundant platy chips of clay.	863–868	6199.1–6194.1
	Dacitic sediments and silt, light brownish-gray (5YR 6/1), slightly porphyritic with aphanitic groundmass, massive. +10F: dacite phenocrysts (3%–5% volume) include pyroxene, biotite, hornblende, plagioclase, and quartz; groundmass weakly sericitized.	868–878	6194.1–6184.1
	Dacitic sediments, medium light gray (N6), slightly porphyritic with aphanitic to finely crystalline groundmass, massive. +10F: flat, platy chips of gray and reddish-brown dacitic sediments: 3%-5% phenocrysts include pyroxene, biotite, hornblende, plagioclase, and quartz; groundmass weakly altered.	878–888	6184.1–6174.1
	Dacitic sediments, medium gray (N5), aphyric, aphanitic to finely crystalline, massive. +10F: flat, platy dacite chips, siliceous groundmass; with alteration. WR sample is clay rich. Note: only 1%–2% of sample was retained on No. 10 sieve.	888–898	6174.1–6164.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tpf, Puye Formation (lower section)	Dacitic sediments, medium gray (N5), aphyric, aphanitic to finely crystalline, massive. +10F: 50% flat, platy dacite chips; 50% white clay (?) shards that appear to be rinds of altered dacitic sediments. Lower 5 ft of the interval contains minor fine-grained sandstone and limonitic clay. WR sample clay rich. Note: only 5% of sample was retained on the No. 10 sieve.	898–908	6164.1–6154.1
	Dacitic sediments, medium gray (N5) and light brownish-gray (5YR 6/1), aphyric, aphanitic to finely crystalline, massive. +10F: 80% flat, platy dacite chips; 20% white, platy clay shards WR sample clay rich.	908–918	6154.1–6144.1
	Dacitic sediments, medium gray (N5) and light brownish-gray (5YR 6/1), aphyric, aphanitic to finely crystalline, massive. +35F: 80% flat, platy dacite chips; 20% white, platy clay shards WR sample clay rich. Note: none of the sample retained on No. 10 sieve.	918–928	6144.1–6134.1
	Dacitic sediments, medium gray (N5), aphyric, aphanitic to finely crystalline, massive. +35F: 100% flat, platy dacite chips; unidentified dark green iridescent mineral present as coatings. Note: none of the sample retained on No. 10 sieve.	928–938	6134.1–6124.1
	Dacitic sediments, medium gray (N5), finely crystalline aphyric to weakly porphyritic with aphanitic groundmass, massive. +35F: 100% flat, platy dacite chips. Note: none of the sample retained on No. 10 sieve.	938–943	6124.1–6119.1
	Dacitic sediments, medium gray (N5) to light brownish-gray (5YR 6/1), finely crystalline aphyric to weakly porphyritic with aphanitic groundmass, massive. +10F: 95%–97% flat, platy dacite chips, minor fine-grained phenocrysts of plagioclase and biotite; 3%–5% white platy flakes of clay or strongly altered dacitic sediments. WR sample clay rich.	943–958	6119.1–6104.1
	Dacitic sediments, medium gray (N5), finely crystalline aphyric to sparsely porphyritic with aphanitic groundmass, massive. +10F: 100% platy dacite chips, fine-grained phenocrysts of plagioclase and biotite; partly altered and bleached.	958–963	6104.1–6099.1
	Dacitic sediments, light gray (N6), finely crystalline aphyric to weakly porphyritic with aphanitic groundmass, massive. +35F: 100% platy dacite chips as in the interval 958–963 ft; partly altered and bleached. None of the sample retained on the No. 10 sieve.	963–973	6099.1–6089.1
	Dacitic sediments, light brownish-gray (5YR 6/1), aphyric, aphanitic, massive. +10F: 100% platy dacite chips, approximately half display strong alteration. WR sample clay rich.	973–983	6089.1–6079.1
	Dacitic sediments, medium gray (N5), aphyric, aphanitic, massive. +10F: 100% platy dacite chips commonly exhibiting sericite alteration and bleaching; minor clay content.	983–988	6079.1–6074.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tpf, Puye Formation (lower section)	Dacitic sediments, grayish-orange pink (5YR 7/2), finely crystalline aphyric to sparsely porphyritic with aphanitic groundmass, massive. +10F: platy dacite chips; clay present as rinds and flakes (less than 5% of sample retained on No. 10 sieve).	988–998	6074.1–6064.1
	Dacitic sediments, light brownish-gray (5YR 6/12), finely crystalline to aphanitic, massive. +10F: none of the sample retained. +35F:100% platy dacite chips. WR sample clay rich.	998–1008	6064.1–6054.1
	Dacitic sediments, grayish-orange pink (5YR 7/2), aphyric, aphanitic, massive. +10F: none of the sample retained. +35F: only 5% of sample retained on No. 35 sieve, platy dacite chips; clay present as rinds and flakes.	1008–1023	6054.1–6039.1
	Dacitic sediments, light brownish-gray (5YR 6/12), finely crystalline to aphanitic, massive. +10F: none of the sample retained. +35F:100% dacite chips exhibit moderate to strong alteration. WR sample clay rich.	1023–1038	6039.1–6024.1
	Dacitic sediments, medium light gray (N5), finely crystalline to aphanitic, massive. +10F: 100% dacite chips with moderate alteration and bleaching. WR sample clay rich.	1038–1043	6024.1–6019.1
	Dacitic sediments, medium light gray (N5), finely crystalline to aphanitic, massive. +10F: none of the sample retained. +35F: 100% dacite chips exhibit moderate sericitic alteration and bleaching. WR sample clay rich.	1043–1068	6019.1–5994.1
	No cuttings sample collected.	1068–1070	5994.1–5992.1
	Volcaniclastic sediments, gravel (GW) with sand, light gray (N6), pebbles (up to 1.5 cm) mostly subrounded. +10F: clasts composed of 70%–80% aphanitic to porphyritic dacites; 10%–15% black vitrophyre (obsidian); 3%–7% distinctive white siliceous clay.	1070–1080	5992.1–5982.1
	Volcaniclastic sediments, sand (SW) with gravel, light gray (N7), pebbles (up to 2.0 cm) angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite.	1080–1085	5982.1–5977.1
	Volcaniclastic sediments, silty sand (SM) with gravel, medium light gray (N6), pebbles (up to 1.0 cm) angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite, latite, and pumice.	1085–1100	5977.1–5962.1
	Volcaniclastic sediments, silty sand (SM), light brownish-gray (5YR 6/1) to pale yellow-orange (10YR 6/2), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite, latite, and minor pumice.	1100–1120	5962.1–5942.1
	Volcaniclastic sediments, silty sand (SM), light brownish-gray (5YR 6/1) to grayish-orange pink (5YR 7/2), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite, latite, and minor pumice.	1120–1140	5942.1–5922.1
	Volcaniclastic sediments, sand (SW) with silt, light brownish-gray (5YR 6/1), clasts angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite, pumice, and minor latite.	1140–1145	5922.1–5917.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tpf, Puye Formation (lower section)	Volcaniclastic sediments, silty sand (SM), grayish-orange pink (5YR 7/2), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite, latite, and pumice.	1145–1165	5917.1–5897.1
	Volcaniclastic sediments, sand (SW) with silt, light brownish-gray (5YR 6/1), clasts angular to rounded. +10F: clasts composed dominantly of dacite with some latite and pumice.	1165–1170	5897.1–5892.1
	Volcaniclastic sediments, silty sand (SM), light brownish-gray (5YR 6/1), clasts angular to subrounded. +10F: clasts composed dominantly of dacite with some pumice and latite.	1170–1185	5892.1–5877.1
	Volcaniclastic sediments, silty sand (SM), grayish-orange pink (5YR 7/2), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite with some rhyolite and pumice.	1185–1200	5877.1–5862.1
	Volcaniclastic sediments, sand (SW) with gravel, light brownish-gray (5YR 6/1), pebble clasts (up to 0.7 cm) angular to rounded. +10F: clasts composed dominantly of dacite. +35F: contains some quartz grains.	1200–1205	5862.1–5857.1
	Volcaniclastic sediments, silty sand (SM), pale yellowish-brown (10YR 6/2), grains angular to subangular. +10F: clasts composed dominantly of dacite with some quartz, minor pumice.	1205–1210	5857.1–5852.1
	Clastic sediments, silty sand (SM), very pale orange (10YR 8/2), sand grains angular to rounded. +10F: clasts composed dominantly of dacite with some quartz, latite, and pumice. +35F: contains greater percentage of quartz. Note: the interval from 1210 to 1325 ft bgs contains increased appearance of quartz and pumice.	1210–1225	5852.1–5837.1
	Clastic sediments, sand (SW) with clay, light brownish-gray (5YR 6/1), grains angular to rounded. +10F: clasts composed dominantly of dacite and pumice with some latite and quartz. +35F: contains greater percentages of quartz.	1225–1230	5837.1–5832.1
	Clastic sediments, clayey sand (SC), pinkish-gray (5YR 8/1), sand grains angular to rounded. +10F: clasts composed dominantly of dacite with some quartz, rhyolite, and pumice. +35F: contains greater percentages of quartz.	1230–1245	5832.1–5817.1
	Clastic sediments, clayey sand (SC), pinkish gray (5YR 8/1), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite and pumice with some latite and quartz. +35F: contains greater percentages of quartz.	1245–1255	5817.1–5807.1
	Clastic sediments, sand (SW) with clay, pinkish-gray (5YR 8/1), sand grains angular to subrounded. +10F: clasts composed dominantly of dacite and pumice with minor rhyolite, latite, and quartz. +35F: contains greater percentages of quartz.	1255–1265	5807.1–5797.1
	No cuttings recovered; lost circulation.	1265–1290	5797.1–5772.1
	Clastic sediments, sand (SW) with silt, pinkish-gray (5YR 8/1), sand grains angular to rounded. +10F: clasts composed dominantly of quartz, microcline, and pumice with minor dacite.	1290–1295	5772.1–5767.1

Geologic Unit	Lithologic Description	Sample Interval (ft bgs)	Elevation Range (ft above msl)
Tpf, Puye Formation (lower section)	Clastic sediments, sand (SW) with silt, pinkish-gray (5YR 8/1), sand grains angular to rounded. +10F: clasts composed dominantly of pumice, quartz, and dacite with minor microcline.	1295–1300	5767.1–5762.1
	Clastic sediments, sand (SW) with silt, pinkish-gray (5YR 8/1), sand grains angular to rounded. +10F: clasts composed dominantly of pumice, with some quartz, minor dacite and microcline.	1300–1305	5762.1–5757.1
	Clastic sediments, silty sand (SM), very pale orange (10YR 8/2), sand grains angular to rounded. +10F: clasts composed dominantly of quartz and microcline with some pumice, dacite, and rhyolite.	1305–1320	5757.1–5742.1
	Clastic sediments, silty sand (SM), grayish-orange pink (5YR 7/2), sand grains angular to rounded. +10F: clasts composed dominantly of quartz, pumice, and dacite with minor microcline and basalt.	1320–1325	5742.1–5737.1
	R-14 BOREHOLE TOTAL DEPTH (TD). = 1327 FT BGS		

Notes:

1. American Society for Testing Materials (ASTM) standards (D 2488-90: Standard Practice and Identification of Soils [Visual-Manual Procedure]) were used to describe the texture of drill chip samples for sedimentary rocks such as alluvium and the Puye Formation. ASTM method D 2488-90 incorporates the Unified Soil Classification System (USCS) as a standard for field examination and description of soils. The following standard USCS symbols were used in the R-14 lithologic log:

SW = well graded sand	SM = silty sand	CH = clay, high plasticity
GW = well graded gravel	GM = silty gravel	SC = clayey /sand
GP = poorly graded gravel	GC = clayey gravel	

2. Cuttings at R-14 were collected from ground surface to 1327 ft bgs at nominal 5-ft intervals and divided into three sample splits: (1) unsieved, or whole rock (WR) sample; (2) +10F sieved fraction (No. 10 sieve equivalent to 2.0 mm); and (3) +35F sieved fraction (No. 35 sieve equivalent to 0.50 mm).
3. The term *percent,* as used in the above descriptions, refers to percent by volume for a given sample component.
4. Color designations such as hue, value, and chroma (e.g., 5YR 5/2) are from the Geological Society of America's Rock Color Chart.

Appendix D

LANL Borehole Video Log
(CD attached to inside back cover)

Appendix E

Schlumberger Geophysical Report/Montage
(CD attached to inside back cover)

Appendix F

Westbay™ Multi-Level Sampling Diagram
(CD attached to inside back cover)

Appendix G

Waste Characterization Data

Los Alamos
NATIONAL LABORATORY

Risk Reduction & Environmental Stewardship Division
Water Quality & Hydrology Group (RRES-WQH)
PO Box 1663, MS K497
Los Alamos, New Mexico 87545
(505) 667-7969/Fax: (505) 665-9344

Date: July 16, 2002
Refer to: RRES-WQH: 02-273

Mr. Curt Frischkorn
Pollution Prevention Section
Ground Water Quality Bureau
New Mexico Environment Department
P.O. Box 26110
Santa Fe, New Mexico 87502

SUBJECT: NOTICE OF INTENT TO DISCHARGE, HYDROGEOLOGIC WORKPLAN WELLS

Dear Mr. Frischkorn:

At our July 11, 2002, meeting at your Santa Fe office (Attendees: Mike Saladen (RRES-WQH), Roy Bohn (RRES-R), Bob Beers (RRES-WQH), John Young (NMED-HWB), and Curt Frischkorn (NMED-GWQB)), we reviewed the Notice of Intent to Discharge (NOI) submitted by Los Alamos National Laboratory to your agency on August 2, 2001, for the Hydrogeologic Workplan Wells. In addition to our general review of the NOI, we discussed the Laboratory's immediate need to discharge approximately 50,000 gallons of containerized drilling fluid from Hydrogeologic Workplan Well R-14. I have addressed both of these topics below.

It was my understanding from our July 11th meeting that both you and Mr. Young were satisfied with the Laboratory's NOI for the Hydrogeologic Workplan Wells with the exception of the NOI Decision Tree (Figure 1.0). Per your request, attached is a revised NOI Decision Tree that incorporates a reference to applicable RCRA regulatory limits' into the decision process. In addition, it was also my understanding that your agency would not require a ground water discharge plan for the discharge of drilling fluid, development water, and purge water from Hydrogeologic Workplan Wells as long as all discharges were compliant with the terms and conditions of the NOI.

In addition to our general discussions about the Hydrogeologic Workplan NOI, we discussed the discharge of approximately 50,000 gallons of containerized drilling fluid produced during the drilling of Hydrogeologic Workplan Well R-14. Per your request, please find the following enclosed water quality data and Material Safety Data Sheets (MSDSs) for the drilling fluid produced from R-14.

Mr. Curt Frischkorn - 2 - July 16, 2002
RRES-WQH:02-273

Water Quality Data. Attachment 1.0 contains water quality data (metals, general chemistry, SVOA, VOA, perchlorate, nitrate, and tritium) for the approximately 50,000 gallons of containerized drilling fluid produced during the drilling of R-14. It should be noted that the data table titled, "ER Water Samples" contains analytical results from two samples, GW14-02-46382 and GW14-02-46383, submitted for metals analysis. These samples were collected from the upper and lower portion of the storage tanks, respectively. Both samples were filtered prior to analysis.

The approximately 50,000 gallons of containerized drilling fluid from R-14 is compliant with New Mexico Water Quality Control Commission (NM WQCC) Regulation 3103 ground water standards with the exception of the following three contaminants:

Contaminant	Max. Result (mg/L)	Min. Result (mg/L)	WQCC ground water standard (mg/L)
Al	42.0	7.69	5.0
Fe	9.25	1.51	1.0
Mn	0.36	0.13	0.2

With the exception of acetone, no VOA or SVOA compounds were detected in R-14 drilling fluids. Acetone, detected at 1.6 mg/L, is present as a byproduct of the drilling additives. No perchlorate or tritium were detected in the R-14 drilling fluid at concentrations greater than analytical laboratory's Method Detection Limits (MDLs). Nitrate/nitrite (as N) was detected at 0.56 mg/L.

MSDS Information. Attachment 2.0 contains Material Safety Data Sheets (MSDSs) for the drilling fluid additives used in the top 1068 feet of the R-14 borehole including the formulation quantities for each product.

The Laboratory requests your agency's permission to discharge the approximately 50,000 gallons of drilling fluid from R-14 in accordance with the August 2, 2001, NOI. Please call me at (505) 667-6969 or Roy Bohn of the Laboratory's Environmental Restoration Project (RRES-R) at (505) 665-5138 if additional information is required.

Sincerely,

Bob Beers
Water Quality & Hydrology Group

BB/am

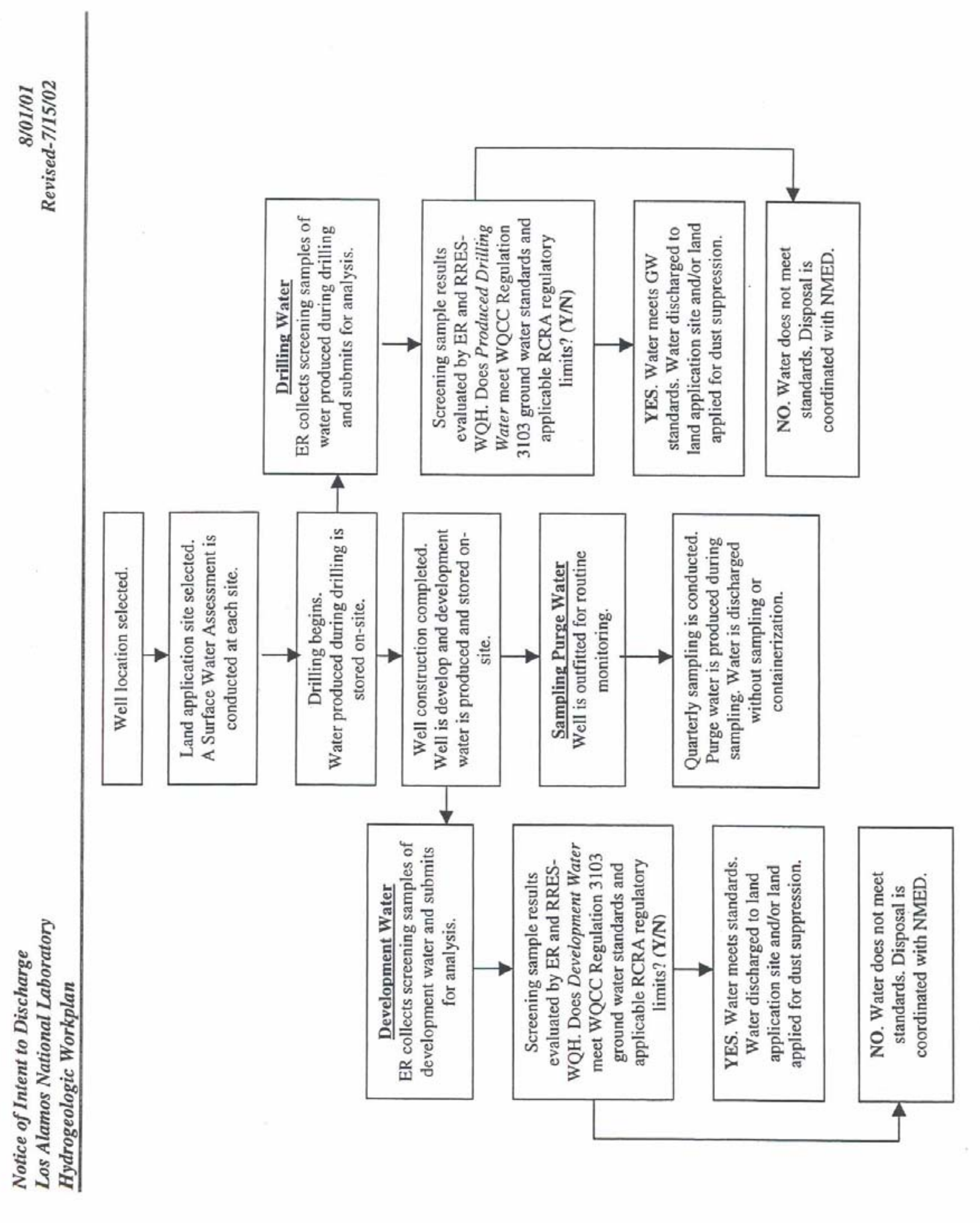

Figure 1.0. Workplan NOI Decision Tree

Los Alamos National Laboratory/University of California
Risk Reduction & Environmental Stewardship (RRES)
Groundwater Protection Program (GPP), MS M992
Los Alamos, New Mexico 87545
(505) 665-4681/FAX (505) 665-4747

National Nuclear Security Administration
Los Alamos Area Office, MS A316
Environmental Restoration Program
Los Alamos, New Mexico 87544
(505) 667-7203/FAX (505) 665-4504

Date: January 22, 2003
Refer to: RRES-GPP:03-006

Mr. John Young, Corrective Action Project Leader
Permits Management Program
NMED – Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building 1
Santa Fe, NM 87505-6303

Butch Tongate
Bureau Chief
NMED-Solid Waste Bureau
P.O. Box 26110
Santa Fe, NM 87502

SUBJECT: MANAGEMENT OF DRILL CUTTINGS FROM HYDROGEOLOGIC WORKPLAN WELLS (R-WELLS)

Dear Messrs. Young and Tongate:

The purpose of this letter is to inform the New Mexico Environment Department Hazardous Waste Bureau (NMED-HWB) and Solid Waste Bureau (NMED-SWB) that the Los Alamos National Laboratory (LANL) will use the cuttings from the drilling of regional aquifer wells for restoration of the drilling site upon completion of drilling activities. The decision to use the cuttings for this purpose is supported by the information included below.

LANL will remove the drill pit liner and leave the cuttings in place as fill for the drill pit upon completion of drilling activities. The drill pits will then be filled to ground level with original site material. The sites will be revegetated and appropriate Best Management Practices will be put in place to prevent erosion. This practice has been used successfully at LANL at all previous regional well drill sites. Unlike previous wells, however, R-Wells 14, 16, 20, 23 and 32 were drilled using drilling fluids, and residuals remain in the cuttings. The attachment to this letter includes data demonstrating that the residuals in the cuttings do not constitute a waste management concern.

Management of the cuttings as part of site restoration is appropriate because the analytical results for the cuttings are consistent with that of purged water being discharged to the ground, per the conditions of Notices of Intent (NOIs) approved by the NMED-Groundwater Bureau (GWB) for R-Wells 14, 16, 20, 23, and 32. The analytes detected in wet cuttings from R-Wells 14 and 32, the minimum, maximum, and mean values, soil geochemical background values, screening levels, and TCLP regulatory limits are shown in the attachment. The screening levels are from "NMED Soil Screening Levels," Revision 1.0, December 18, 2000, with the exception of acetone, 4-methyl-2-pentanone, n-propylbenzene, and 1,2,4-trimethylbenzene, which are Environmental Protection Agency (EPA) screening levels. ESLs are from the ECORISK database, version 1-5, September 2002. Analytes are compared to background values, where available. If background values are unavailable,

Attachment

Analytes Detected in Wet Cuttings for Wells (R-14, R-32)

Detected Analyte	Minimum Value	Maximum Value	Mean Value	Soil Geochemical Background Value	Screening Action Levels	Ecological Screening Levels	TCLP Regulatory Limit
Radionuclides (pCi/g):							
Am-241 (alpha spec)	0	0	0	0.013	NA	NA	NA
Cs-137 (gamma spec)	0	0	0	1.65	NA	NA	NA
Pu-238 (alpha spec)	0	0	0	0.023	NA	NA	NA
Pu-239 (alpha spec)	0	0	0	0.054	NA	NA	NA
Sr-90 (proportional counting)	0	0	0	1.31	NA	NA	NA
Tritium (liquid scintillation)	0.035	31,860	10.6	0.17 (Qbt 3)*	890	36,000	NA
Th-232 (gamma spec)	0	1.25	0.417	2.33	NA	NA	NA
U-234 (alpha spec)	1.10	1.28	1.19	2.59	NA	NA	NA
U-235 (alpha spec)	0	0.073	0.037	0.2	NA	NA	NA
U-238 (alpha spec)	1.13	1.23	1.19	2.29	NA	NA	NA
Organics (EPA 8260-B & 8270-C, mg/kg):							
Acetone (isopropyl alcohol)	2.9	17.6	14.7	Unavailable	1,600	3.8	NA
Benzene	0	0.010	0.002	Unavailable	6.4	55	0.5 mg/L
Bromomethane	0	0.620	0.160	Unavailable	3.7	NA	NA
Chloroform	0	0.0078	0.0018	Unavailable	0.38	28	6 mg/L
Chloromethane	0	0.0079	0.0026	Unavailable	12.0	NA	NA
Ethylbenzene	0	0.015	0.003	Unavailable	68	NA	NA
4-Methyl-2-pentanone	0	0.033	0.007	Unavailable	790	NA	NA
Methylene chloride	0	0.710	0.182	Unavailable	8.9	7.1	NA
n-Propylbenzene	0	0.0065	0.001	Unavailable	140	NA	NA
Toluene	0	0.510	0.138	Unavailable	180	70	NA
1,2,4-Trimethylbenzene	0	0.038	0.008	Unavailable	52	NA	NA
Xylenes (total)	0	0.064	0.013	Unavailable	63	5.4	NA
High Explosives (EPA 8330, mg/kg) :							
No compounds were detected.							
PCBs (EPA 8082, mg/kg):							
No compounds were detected.							
Total Inorganics (EPA 6010-B, mg/kg):							
Aluminum	1.93	9,670	3,228	29,200	NA	NA	NA
Antimony	0	0.068	0.023	0.83	NA	NA	NA
Arsenic	0.005	1.57	0.528	8.17	NA	NA	NA
Barium	0.018	61.3	20.5	295	NA	NA	NA
Beryllium	0	0.333	0.111	1.83	NA	NA	NA
Cadmium	0	0.285	0.095	0.40	NA	NA	NA
Calcium	45.2	9,370	3,392	6,120	NA	NA	NA
Chromium	0.0034	29.7	10.2	19.3	NA	NA	NA
Cobalt	0	15.9	5.3	8.64	NA	NA	NA
Copper	0.008	24.3	8.1	14.7	NA	NA	NA
Iron	0	28,170	9,390	21,500	23,000	NA	NA
Lead	0	2.69	0.898	22.3	NA	NA	NA
Magnesium	0.08	14,390	4,800	4,610	NA	NA	NA
Manganese	0	501	167.3	671	NA	NA	NA
Mercury	0	0.0011	0.0004	0.1	NA	NA	NA
Nickel	0.004	48.1	16.0	15.4	1,500	NA	NA
Potassium	37.3	733	390.8	3,460	NA	NA	NA
Selenium	0	1.75	0.59	1.52	NA	NA	NA
Silver	0	0.084	0.028	1	NA	NA	NA
Sodium	227	2,620	1,260	915	NA	NA	NA
Thallium	0	0.107	0.036	0.73	NA	NA	NA
Vanadium	0	54.8	18.3	39.6	NA	NA	NA
Zinc	0	42	14.0	48.8	NA	NA	NA
TCLP Inorganics (EPA 1311/6010-B, mg/L):							
Arsenic	0	0	0	NA	NA	NA	5
Barium	0.152	0.241		NA	NA	NA	100
Cadmium	0	0	0	NA	NA	NA	1
Chromium	0	0.0169		NA	NA	NA	5
Lead	0	0.003		NA	NA	NA	5
Mercury	0	0	0	NA	NA	NA	0.2
Selenium	0	0	0	NA	NA	NA	1
Silver	0	0	0	NA	NA	NA	5

* Background value is calculated from Bandelier Tuff unit 3 (Qbt 3) value of 0.3 pCi/mL at 18.5% moisture concentration.

HYDROGEOLOGIC WORKPLAN
WELL R-14

CONTAINERIZED DRILLING FLUIDS

Contents:

ANALYTICAL REPORTS

- GENERAL CHEMISTRY
- METALS
- PERCHLORATE
- NITRATE/NITRITE
- TRITIUM
- VOA
- SVOA

Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

ER WATER SAMPLES

SAMPLE ID	DESCRIPTION	DATE MM/DD/YY	ER Req#	Ag ppm	Al ppm	Std.D. +/-	As ppm	Std.D. +/-	B ppm	Std.D. +/-	Ba ppm
GW14-02-46328	Frac tank mud sample, anions	06/21/02	889S	---	---	---	---	---	---	---	---
GW14-02-46382	Frac tank mud sample, metals	06/26/02	897S	<0.001	7.69	0.02	0.0081	0.0001	0.08	0.01	0.042
GW14-02-46383	Frac tank mud sample, metals	06/26/02	897S	<0.001	42.0	0.1	0.0069	0.0002	0.10	0.01	0.15

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Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

SAMPLE ID	Std.D. +/-	Be ppm	Br ppm	Ca ppm	Std.D. +/-	Cd ppm	Cl ppm	ClO3 ppm	ClO4 ppm	Co ppm	Std.D. +/-	Cr ppm	Std.D. +/-	Cs ppm
GW14-02-46328	---	---	0.27	---	---	---	5.59	<0.05	<0.01	---	---	---	---	---
GW14-02-46382	0.001	<0.001	---	12.9	0.1	<0.001	---	---	---	0.0022	0.0001	0.015	0.001	0.0017
GW14-02-46383	0.01	<0.001	---	29.6	0.2	<0.001	---	---	---	0.009	0.001	0.016	0.001	0.0012

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Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

SAMPLE ID	Std.D. +/-	Cu ppm	Std.D. +/-	F ppm	Fe ppm	Std.D. +/-	Hg ppm	Std.D. +/-	K ppm	Std.D. +/-	Li ppm	Std.D. +/-	Mg ppm	Std.D. +/-	Mn ppm
GW14-02-46328	---	---	---	0.48	---	---	---	---	---	---	---	---	---	---	---
GW14-02-46382	0.0001	0.027	0.001	---	1.51	0.01	0.0020	0.0001	13.8	0.2	0.15	0.01	3.76	0.05	0.13
GW14-02-46383	0.0001	0.025	0.001	---	9.25	0.07	0.0008	0.0001	16.5	0.1	0.13	0.01	11.4	0.1	0.36

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Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

SAMPLE ID	Std.D. +/-	Mo ppm	Std.D. +/-	Na ppm	Std.D. +/-	Ni ppm	Std.D. +/-	NO2 ppm	NO3 ppm	Oxalate ppm	Pb ppm	Std.D. +/-	pH Lab	PO4 ppm
GW14-02-46328	---	---	---	---	---	---	---	1.64	0.27	<0.05	---	---	---	0.50
GW14-02-46382	0.01	0.13	0.01	285	2	0.008	0.001	---	---	---	0.0047	0.0001	6.73	---
GW14-02-46383	0.01	0.20	0.01	374	1	0.018	0.001	---	---	---	0.011	0.001	6.72	---

Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

SAMPLE ID	Rb ppm	Std.D. +/-	Sb ppm	Std.D. +/-	Se ppm	Std.D. +/-	Si ppm	Std.D. +/-	Sn ppm	Std.D. +/-	Sr ppm	Std.D. +/-	Th ppm	Std.D. +/-	Ti ppm
GW14-02-46328	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
GW14-02-46382	0.030	0.001	0.0040	0.0001	0.004	0.001	37.4	0.6	<0.001		0.16	0.01	0.014	0.001	0.092
GW14-02-46383	0.026	0.001	0.0031	0.0001	0.003	0.001	114	2	0.0031	0.0001	0.43	0.01	0.030	0.001	0.45

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Hydrogeologic Workplan Well R-14
Water Quality Data-Drilling Fluid

ER

SAMPLE ID	Std.D. +/-	Tl ppm	U ppm	Std.D. +/-	V ppm	std.D. +/-	Zn ppm	Std.D. +/-
GW14-02-46328	---	---	---	---	---	---	---	---
GW14-02-46382	0.001	<0.001	0.0059	0.0001	0.013	0.001	0.022	0.001
GW14-02-46383	0.01	<0.001	0.010	0.001	0.016	0.001	0.039	0.001

Page 6

LOS ALAMOS NATIONAL LABORATORY Preliminary

Client Sample ID: GW14-02-46382

Severn Trent Laboratories - Radiochemistry

Lab Sample ID: F2F260140-001
Work Order: E3PPG
Matrix: WATER

Date Collected: 06/21/02 0000
Date Received: 06/26/02 0900

Parameter	Result	Qual	Total Uncert. (2 σ+/-)	MDC	Prep Date	Analysis Date	Batch #	Yld %
TRITIUM (Distill) by EPA 906.0 MOD			pCi/L		906.0 MOD			
Tritium	20	U	140	230	07/08/02	07/08/02	2189221	

NOTE(S)

Data are incomplete without the case narrative.

MDC is determined by instrument performance only.

Bold results are greater than the MDC

U Result is less than the sample detection limit.

SEVERN TRENT LABORATORIES, INC.

PRELIMINARY DATA SUMMARY

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Los Alamos National Laboratory
Los Alamos Non-Rad
Project Number: 888S

Lot #: F2F260137

PAGE 3

Date Reported: 7/10/02

Client Sample ID: GW14-02-46328
Sample #: 001 Date Sampled: 06/21/02 Date Received: 06/26/02 Matrix: WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
Volatile Organics by GC/MS				Reviewed
Dichlorodifluoromethane	ND	50	ug/L	SW846 8260B
Chloromethane	5.9 J	50	ug/L	SW846 8260B
Vinyl chloride	ND	50	ug/L	SW846 8260B
Bromomethane	ND	50	ug/L	SW846 8260B
Chloroethane	ND	50	ug/L	SW846 8260B
Trichlorofluoromethane	ND	50	ug/L	SW846 8260B
Trichlorotrifluoroethane	ND	25	ug/L	SW846 8260B
Acetone	1600 B	250	ug/L	SW846 8260B
1,1-Dichloroethene	ND	25	ug/L	SW846 8260B
Iodomethane	ND	25	ug/L	SW846 8260B
Methylene chloride	29	25	ug/L	SW846 8260B
Carbon disulfide	ND	25	ug/L	SW846 8260B
1,1-Dichloroethane	ND	25	ug/L	SW846 8260B
2-Butanone	ND	120	ug/L	SW846 8260B
2,2-Dichloropropane	ND	25	ug/L	SW846 8260B
1,2-Dichloroethene (total)	ND	25	ug/L	SW846 8260B
Chloroform	ND	25	ug/L	SW846 8260B
Bromochloromethane	ND	25	ug/L	SW846 8260B
1,1,1-Trichloroethane	ND	25	ug/L	SW846 8260B
1,1-Dichloropropene	ND	25	ug/L	SW846 8260B
Carbon tetrachloride	ND	25	ug/L	SW846 8260B
1,2-Dichloroethane	ND	25	ug/L	SW846 8260B
Benzene	ND	25	ug/L	SW846 8260B
Trichloroethene	ND	25	ug/L	SW846 8260B
1,2-Dichloropropane	ND	25	ug/L	SW846 8260B
Bromodichloromethane	ND	25	ug/L	SW846 8260B
Dibromomethane	ND	25	ug/L	SW846 8260B
4-Methyl-2-pentanone	ND	120	ug/L	SW846 8260B
cis-1,3-Dichloropropene	ND	25	ug/L	SW846 8260B
Toluene	ND	25	ug/L	SW846 8260B
1,1,2-Trichloroethane	ND	25	ug/L	SW846 8260B
2-Hexanone	ND	120	ug/L	SW846 8260B
1,3-Dichloropropane	ND	25	ug/L	SW846 8260B
Tetrachloroethene	ND	25	ug/L	SW846 8260B
Chlorodibromomethane	ND	25	ug/L	SW846 8260B
1,2-Dibromoethane	ND	25	ug/L	SW846 8260B

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SEVERN TRENT LABORATORIES, INC.

PRELIMINARY DATA SUMMARY

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Los Alamos National Laboratory
Lot #: F2F260137 Los Alamos Non-Rad Date Reported: 7/10/02 PAGE 4
Project Number: 888S

Client Sample ID: GW14-02-46328
Sample #: 001 Date Sampled: 06/21/02 Date Received: 06/26/02 Matrix: WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD	
Volatile Organics by GC/MS					Reviewed
Chlorobenzene	ND	25	ug/L	SW846 8260B	
1,1,1,2-Tetrachloroethane	ND	25	ug/L	SW846 8260B	
Ethylbenzene	ND	25	ug/L	SW846 8260B	
Xylenes (total)	ND	25	ug/L	SW846 8260B	
Styrene	ND	25	ug/L	SW846 8260B	
Bromoform	ND	25	ug/L	SW846 8260B	
Isopropylbenzene	ND	25	ug/L	SW846 8260B	
1,1,2,2-Tetrachloroethane	ND	25	ug/L	SW846 8260B	
1,2,3-Trichloropropane	ND	25	ug/L	SW846 8260B	
n-Propylbenzene	ND	25	ug/L	SW846 8260B	
trans-1,3-Dichloropropene	ND	25	ug/L	SW846 8260B	
Bromobenzene	ND	25	ug/L	SW846 8260B	
2-Chlorotoluene	ND	25	ug/L	SW846 8260B	
1,3,5-Trimethylbenzene	ND	25	ug/L	SW846 8260B	
4-Chlorotoluene	ND	25	ug/L	SW846 8260B	
tert-Butylbenzene	ND	1200	ug/L	SW846 8260B	
1,2,4-Trimethylbenzene	ND	25	ug/L	SW846 8260B	
sec-Butylbenzene	ND	25	ug/L	SW846 8260B	
p-Isopropyltoluene	ND	25	ug/L	SW846 8260B	
1,3-Dichlorobenzene	ND	25	ug/L	SW846 8260B	
1,4-Dichlorobenzene	ND	25	ug/L	SW846 8260B	
n-Butylbenzene	ND	25	ug/L	SW846 8260B	
1,2-Dichlorobenzene	ND	25	ug/L	SW846 8260B	
1,2-Dibromo-3-chloro-propane	ND	25	ug/L	SW846 8260B	

J Estimated result. Result is less than RL.
E Estimated result. Result concentration exceeds the calibration range.

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD	
Semivolatile Organic Compounds by GC/MS					In Review
3-Methylphenol & 4-Methylphenol	ND	20	ug/L	SW846 8270C	
Pyridine	ND	20	ug/L	SW846 8270C	
N-Nitrosodimethylamine	ND	20	ug/L	SW846 8270C	
Phenol	ND	10	ug/L	SW846 8270C	
Aniline	ND	20	ug/L	SW846 8270C	
bis(2-Chloroethyl)-ether	ND	10	ug/L	SW846 8270C	

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SEVERN TRENT LABORATORIES, INC.

PRELIMINARY DATA SUMMARY

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Los Alamos National Laboratory — PAGE 5

Lot #: F2F260137 — Los Alamos Non-Rad — Date Reported: 7/10/02

Project Number: 888S

Client Sample ID: GW14-02-46328

Sample #: 001 Date Sampled: 06/21/02 Date Received: 06/26/02 Matrix: WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
Semivolatile Organic Compounds by GC/MS				In Review
2-Chlorophenol	ND	10	ug/L	SW846 8270C
1,3-Dichlorobenzene	ND	10	ug/L	SW846 8270C
1,4-Dichlorobenzene	ND	10	ug/L	SW846 8270C
Benzyl alcohol	ND	10	ug/L	SW846 8270C
1,2-Dichlorobenzene	ND	10	ug/L	SW846 8270C
2-Methylphenol	ND	10	ug/L	SW846 8270C
2,2'-oxybis(1-Chloropropane)	ND	10	ug/L	SW846 8270C
N-Nitrosodi-n-propyl-amine	ND	10	ug/L	SW846 8270C
Hexachloroethane	ND	10	ug/L	SW846 8270C
Nitrobenzene	ND	10	ug/L	SW846 8270C
Isophorone	ND	10	ug/L	SW846 8270C
2-Nitrophenol	ND	10	ug/L	SW846 8270C
2,4-Dimethylphenol	ND	10	ug/L	SW846 8270C
bis(2-Chloroethoxy) methane	ND	10	ug/L	SW846 8270C
Benzoic acid	ND	20	ug/L	SW846 8270C
2,4-Dichlorophenol	ND	10	ug/L	SW846 8270C
1,2,4-Trichloro-benzene	ND	10	ug/L	SW846 8270C
Naphthalene	ND	10	ug/L	SW846 8270C
4-Chloroaniline	ND	20	ug/L	SW846 8270C
Hexachlorobutadiene	ND	10	ug/L	SW846 8270C
4-Chloro-3-methylphenol	ND	20	ug/L	SW846 8270C
2-Methylnaphthalene	ND	10	ug/L	SW846 8270C
Hexachlorocyclopenta-diene	ND	10	ug/L	SW846 8270C
2,4,6-Trichloro-phenol	9.5 J	10	ug/L	SW846 8270C
2,4,5 Trichloro phenol	5.0 J	10	ug/L	SW846 8270C
2-Chloronaphthalene	ND	10	ug/L	SW846 8270C
2-Nitroaniline	ND	50	ug/L	SW846 8270C
Dimethyl phthalate	ND	10	ug/L	SW846 8270C
Acenaphthylene	110	10	ug/L	SW846 8270C
2,6-Dinitrotoluene	ND	10	ug/L	SW846 8270C
3-Nitroaniline	ND	50	ug/L	SW846 8270C

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SEVERN TRENT LABORATORIES, INC.

PRELIMINARY DATA SUMMARY

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Los Alamos National Laboratory — PAGE 6

Lot #: F2F260137 — Los Alamos Non-Rad — Date Reported: 7/10/02

Project Number: 888S

Client Sample ID: GW14-02-46328

Sample #: 001 Date Sampled: 06/21/02 Date Received: 06/26/02 Matrix: WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
Semivolatile Organic Compounds by GC/MS				In Review
Acenaphthene	ND	10	ug/L	SW846 8270C
2,4-Dinitrophenol	ND	50	ug/L	SW846 8270C
4-Nitrophenol	ND	50	ug/L	SW846 8270C
Dibenzofuran	ND	10	ug/L	SW846 8270C
2,4-Dinitrotoluene	ND	10	ug/L	SW846 8270C
Diethyl phthalate	ND	10	ug/L	SW846 8270C
Fluorene	ND	10	ug/L	SW846 8270C
4-Chlorophenyl phenyl ether	ND	10	ug/L	SW846 8270C
4-Nitroaniline	ND	20	ug/L	SW846 8270C
4,6-Dinitro-2-methylphenol	ND	50	ug/L	SW846 8270C
N-Nitrosodiphenylamine	ND	10	ug/L	SW846 8270C
Azobenzene	ND	20	ug/L	SW846 8270C
4-Bromophenyl phenyl ether	ND	10	ug/L	SW846 8270C
Hexachlorobenzene	ND	10	ug/L	SW846 8270C
Pentachlorophenol	ND	50	ug/L	SW846 8270C
Phenanthrene	ND	10	ug/L	SW846 8270C
Anthracene	ND	10	ug/L	SW846 8270C
Fluoranthene	ND	10	ug/L	SW846 8270C
Pyrene	ND	10	ug/L	SW846 8270C
Butyl benzyl phthalate	ND	10	ug/L	SW846 8270C
Benzo(a)anthracene	ND	10	ug/L	SW846 8270C
3,3'-Dichlorobenzidine	ND	20	ug/L	SW846 8270C
Chrysene	ND	10	ug/L	SW846 8270C
bis(2-Ethylhexyl) phthalate	**7.7 J**	**10**	**ug/L**	**SW846 8270C**
Di-n-butyl phthalate	ND	10	ug/L	SW846 8270C
Di-n-octyl phthalate	ND	10	ug/L	SW846 8270C
Benzo(b)fluoranthene	ND	10	ug/L	SW846 8270C
Benzo(k)fluoranthene	ND	10	ug/L	SW846 8270C
Benzo(a)pyrene	ND	10	ug/L	SW846 8270C
Indeno(1,2,3-cd)pyrene	ND	10	ug/L	SW846 8270C
Benzo(ghi)perylene	ND	10	ug/L	SW846 8270C
Dibenz(a,h)anthracene	ND	10	ug/L	SW846 8270C

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